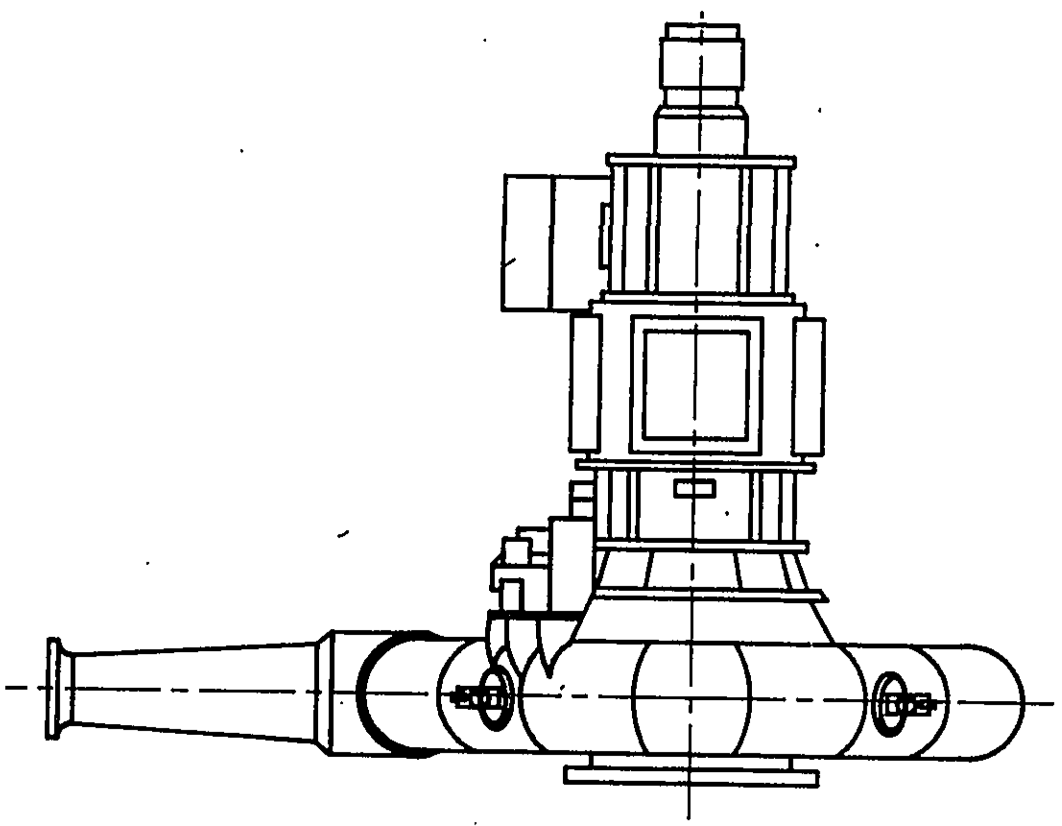
FILE COPY

HANALEI RIVER HYDROELECTRIC PROJECT

KAUAI, HAWAII



DRAFT

ENVIRONMENTAL IMPACT STATEMENT

FOR

ISLAND POWER COMPANY INC.

PREPARED BY:

Bingham Engineering
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116
(801) 532-2520

FEBRUARY 1987

FILE COPY

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February 1987

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B. PROJECT DESCRIPTION

B-1 DETAILED MAPS

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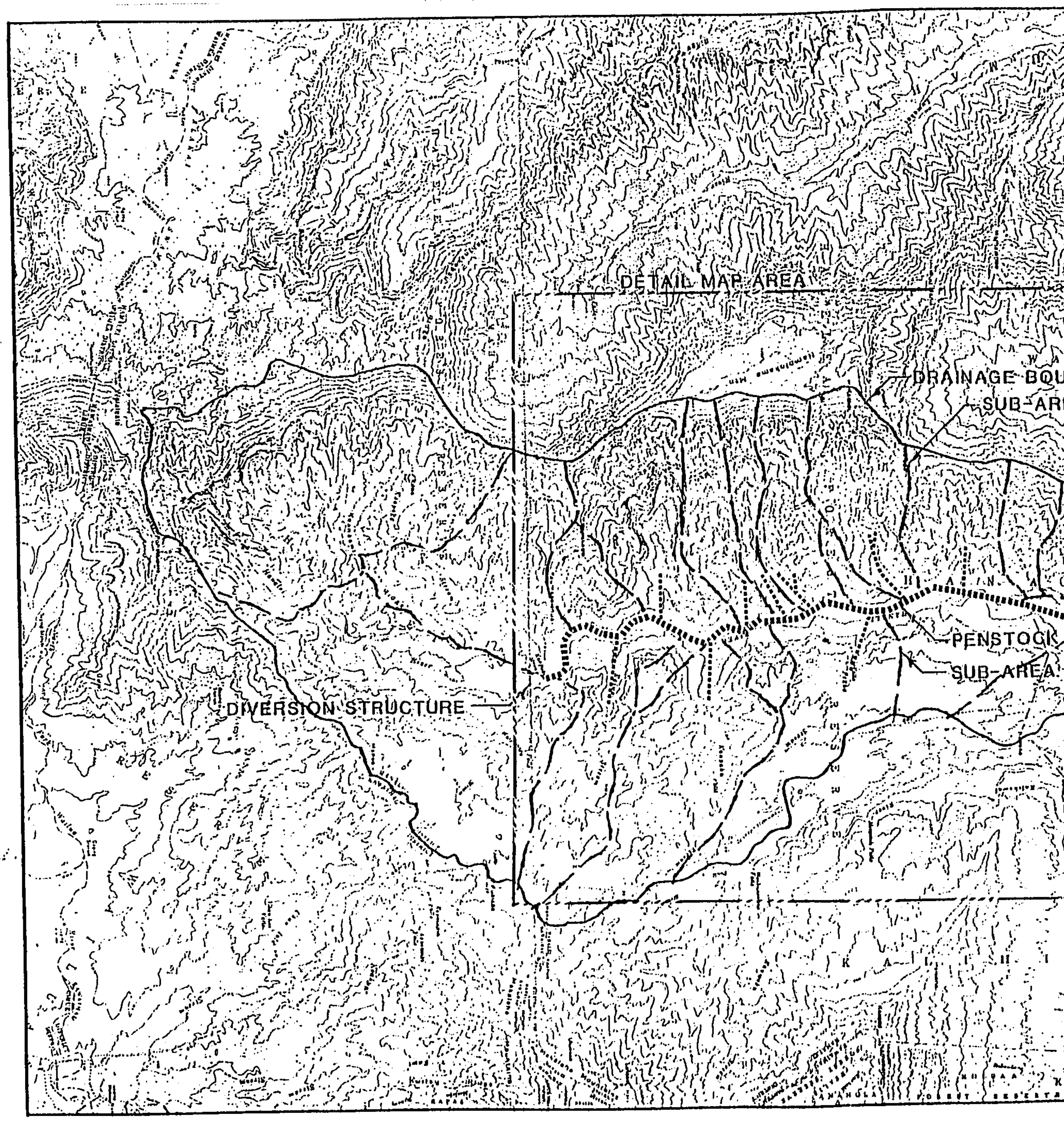

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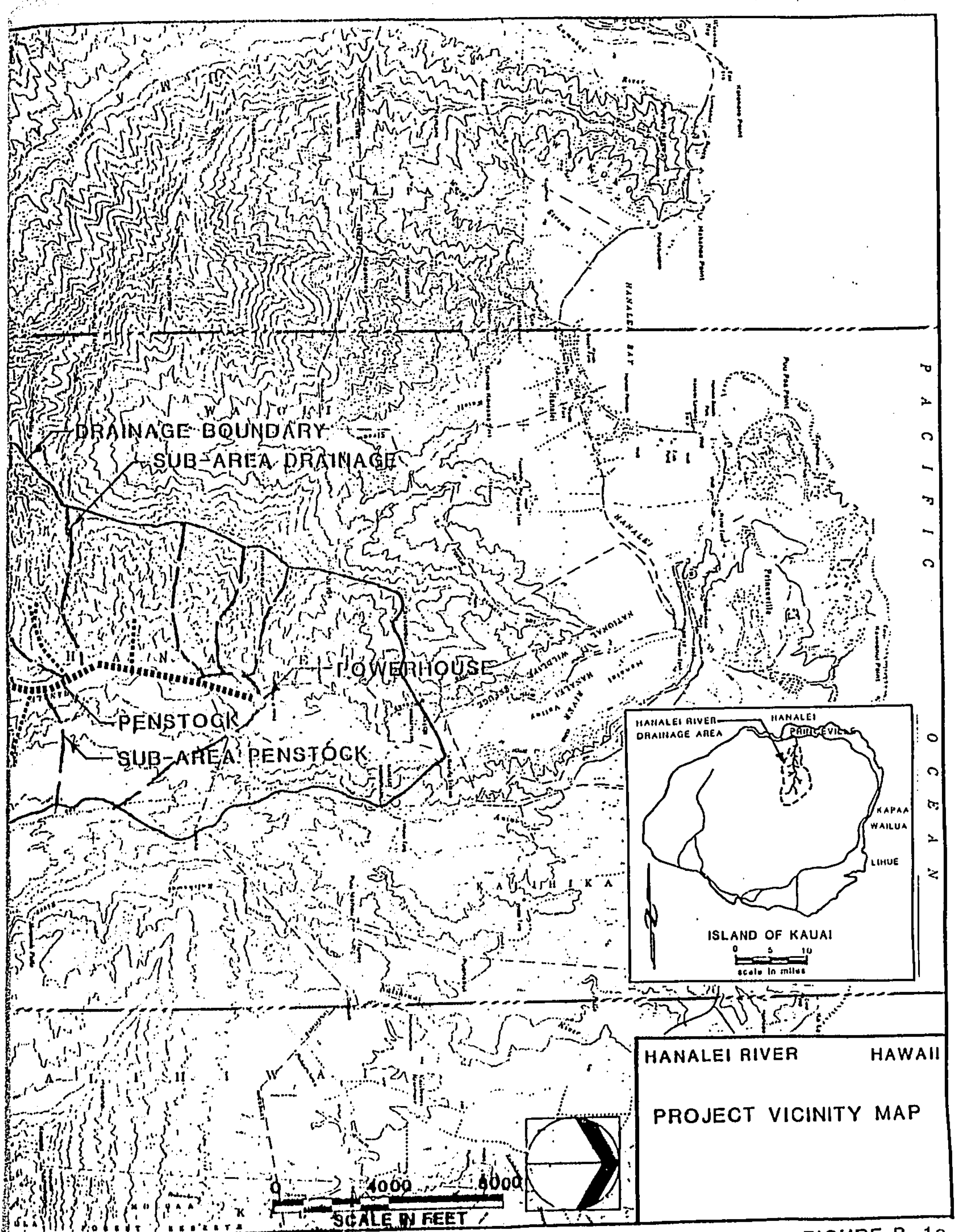

FIGURE B-1a

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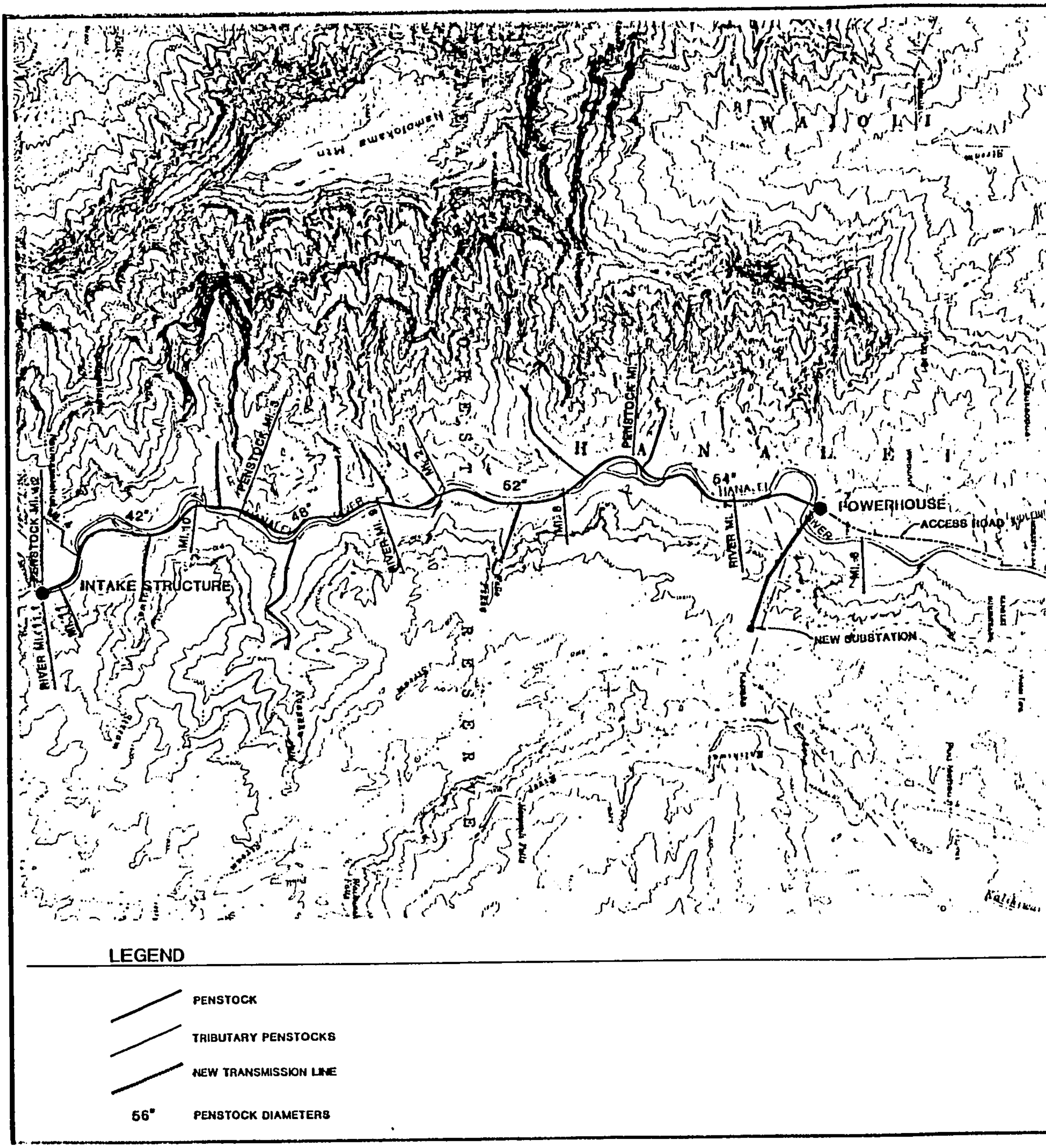

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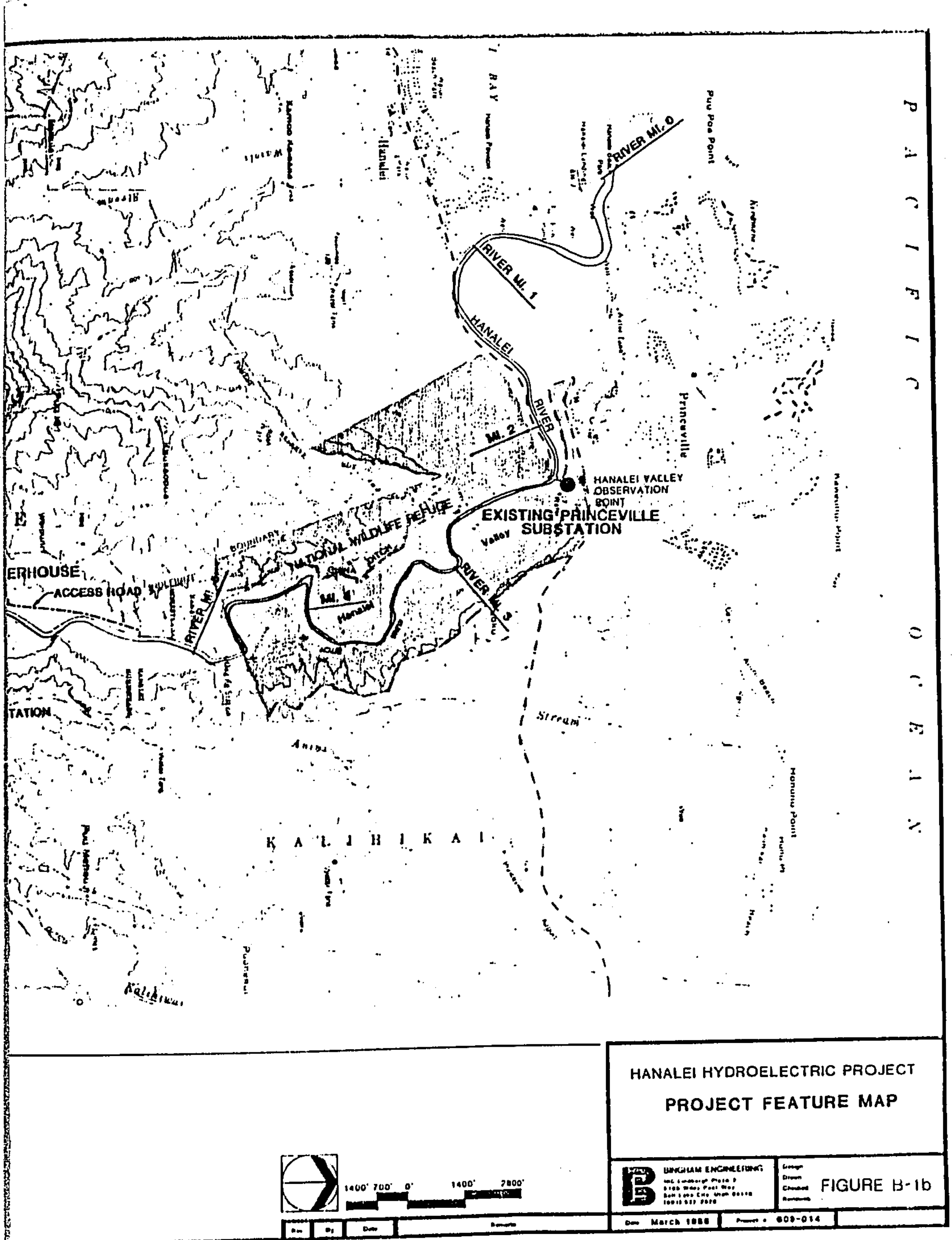


B-2 STATEMENT OF OBJECTIVES

B-2a PURPOSE

The purpose of this study is to establish the environmental and financial feasibility of a potential hydroeletric power facility for the Hanalei River Basin, Island of Kauai, State of Hawaii.

B-2b NEED

Unlike many new energy developments, the technology of hydropower has been firmly established. Over the past decade, hydropower as a renewable energy resource has rekindled interest for its role in alternative energy development nationally and in the State of Hawaii. The Island of Kauai, similar to most insular areas, is highly dependent upon petroleum-based fuels for the production of electricity. This condition has led to relatively high costs of energy production and reliance on a potentially volatile worldwide fuel market. The goal is to alleviate oil dependence in energy production and greater energy self-sufficiency for the Island of Kauai.

The economic aspects of the project are significant and beneficial. The benefits are derived solely from displacement of energy from Kauai Electric's system assuming fuel price escalation and power-on-line effective date of 1988. The project would contribute significantly toward the goals of alleviation of oil dependence and increased energy self-sufficiency. The Hanalei River Hydroelectric Project as currently proposed will cost $15 million to construct and would produce approximately 29.5 million kilowatt hours of electricity per year or about 8% of the total energy consumed on the Island of Kauai. The Project would supplant the need to import 60,000 barrels of oil annually and service an equivalent of 5,500 households of 17,500 individuals, assuming the current rate of fuel oil utilization and household demands are maintained.

B-3 GENERAL DESCRIPTION OF THE ACTION'S TECHNICAL, ECONOMIC, SOCIAL AND ENVIRONMENTAL CHARACTERISTICS

B-3a TECHNICAL

Island Power Company, Inc. proposes to construct and operate a hydroelectric powerplant on the Hanalei River, Island of Kauai, State of Hawaii. The project will cost approximately $15 million dollars to construct and will generate about 29.5 million kilowatt hours of electricity per year. The powerplant will have a maximum generating capacity of approximately 8,000 kilowatts with a maximum hydraulic capacity of 238 cubic feet per second ("cfs").

The proposed project will utilize stream flows from the upper Hanalei River and several of its small tributaries to generate hydroelectric power.

A new diversion weir will be constructed on the upper Hanalei River approximately 11.1 river miles upstream from the mouth. The intake structure will be screened to prevent entrainment of fish. Screening criteria will be established in conjunction with the U.S. Fish & Wildlife Service and the Department of Land & Natural Resources. An above ground pipeline varying in diameter from 54 inches to 72 inches and approximately 23,325 feet long will convey the water from the new diversion weir to a powerhouse approximately 6.5 river miles upstream from the mouth and approximately 1 river mile upstream from the China Ditch Diversion. The flow will then be discharged from the powerhouse and return to the natural channel of the Hanalei River.

A new 69 KV transmission line approximately 0.6 miles in length will be constructed to interconnect the project with Kauai Electric at the existing overhead transmission line in the Hanalei basin. A new substation will be constructed at the existing transmission line to facilitate the delivery of the project power into the Kauai Electric System. The project power will be sold to Kauai Electric which will then be distributed to their customers.

B-3b ECONOMIC

The economic aspects of the project are significant and beneficial. The benefits are derived solely from displacement of Kauai Electric's system energy and assume fuel price escalation and a power-on-line effective date of 1988. The project would contribute significantly toward the goals of the alleviation of oil dependence and increased energy self-sufficiency. The hydroelectric facility would supplant the need to import 60,000 barrels of oil annually and service an equivalent of 5,500 households or 17,500 individuals, assuming the current rates of fuel oil utilization and household demands are maintained.

There will be an increase in employment opportunities for local laborers and construction companies as a result of the construction of the proposed project. Local suppliers will also be used for concrete, backfill materials and other major components of the project.

The project will cost $15 million to construct, which includes all direct and indirect construction costs, easements and rights-of-way, land and agricultural damages, and interest during construction. Operations and maintenance of the project will also involve local personnel.

The following list is an itemization of the total project costs.

COST ESTIMATES

BASIS FOR COST ESTIMATES

Construction Cost. The basic assumptions for the construction cost estimates were as follows:

a. The contractor and labor would be Kauai, Hawaii based. Labor would be performed on 6-8 hours shifts per week.

b. Construction period would be 12 months.

c. Escalation to mid-point of construction was included. Annual construction inflation would be 9 percent. Contingencies are 10 percent. However, for turbine/generator and related electrical/mechanical items, based on manufacturer's bid prices, contingencies are 10 percent. Transmission line contingencies are 10 percent.

d. Excavation below the loose rock would require blasting for rock removal. The loose rock would be composed of loose boulders and cobbles with 30% boulders.

e. Mechanical and electrical equipment would be from continental United States. Installation labor from the mainland would be required for turbine-generator features. Itemized costs include delivery costs to site.

f. Price level for all work is July, 1988.

Indirect Costs. Indirect costs include technical and administrative costs associated with the design and construction of the project.

a. **Engineering and Design.** These indirect costs would be for engineering efforts in the preparation of design memoranda; construction plans and specifications; and engineering during construction. All associated overhead amounts are included in the Engineering and Design totals.

b. **Supervision and Administration.** The construction contract would include contract administration and field inspection. Associated overhead amounts are included in the total.

c. **Right-of-Way Indirect Costs.** Indirect costs included the management of construction rights-of-way, easements and inter-agency coordination during construction.

Easements. The costs required to acquire construction rights-of-way would be borne by the developer. These costs included purchase of lands in fee and compensation for damages to agricultural lands to private interests. Lands under ownership by the State of Hawaii will be leased on a fair market value basis.

Operational and Maintenance and Replacement Costs. These costs are annual costs required to keep all facilities in good working condition and repair.

Interest During Construction (IDC). Interest during construction accounts for the capital incurred during the construction period. The computed amount is to be included in the total project investment costs and forms a portion of the average annual costs. The turbine-generator procurement process is normally an independent contract. Hence, construction inflation was computed on the basis of 12 months and IDC was computed on the basis of 12 months.

Table B-3b-1 COST ESTIMATE

HANALEI RIVER HYDROELECTRIC PROJECT

ENGINEERS ESTIMATE OF COST
SCHEDULE OF VALUES

ALTERNATIVE 3

Diversion Structure

Concrete

Wing Walls		17 yds
Floor		39 yds
Inlet Chamber		18 yds
Cut-Off Wall		6 yds
Misc		8 yds
		88 yds
	88 cu-yds @ 500/yd	$44,000
Gates		22,112
Trash Racks		8,845
Walkways/Grating		8,845
Bulkhead provisions		6,634
Electrical power from powerhouse (material only)		5,528
Floodlight and pole		663
Rock anchors		8,845
Excavation		55,280
Rock removal		33,168
Backfilling		11,056
Revegetation		2,211
Misc Items		44,224
		$251,411
10% Engineering and Construction Mgt.		25,141
10% Contingency		25,141
Intake Structure Total		$301,693

HANALEI RIVER HYDROELECTRIC PROJECT

COST ESTIMATE (CONT)

Penstock

4000'- 54" x 0.250"	106 Max Q	$59.94 = 239,760
2300'- 56" x 0.250"	119	62.16 = 142,968
2500'- 58" x 0.250"	140	64.38 = 160,950
1800'- 62" x 0.250"	164	68.81 = 123,858
600'- 64" x 0.250"	175	71.04 = 42,624
1500'- 64" x 0.250"	180	71.04 = 106,560
2200'- 66" x 0.313"	192	86.60 = 190,520
1600'- 68" x 0.375"	212	102.98 = 164,768
1400'- 70" x 0.375"	227	106.03 = 148,442
3300'- 72" x 0.438"	238	123.60 = 407,880
2125'- 72" x 0.500"	238	138.16 = 293,590

	507,898
Shipping and Delivery	$2,529,818
	252,982
10% Contingency	$2,782,800
Penstock Total	

Saddles & Pipeline - Misc.

Assume 40' spacing for upper 6500' - 135
44' spacing for next 6500' - 120
48' spacing for next 10,000' - 170

Total **425**

For each saddle - assume an average of 2.0 cu. yds. conc. 425 X 2.0 X 600 $/yd. =	$ 510,000
Pipe straps, bolts etc. 425 X 376/Saddle	$ 159,800
Expansion joints - At 400' spacing = 48 joints	$ 48,000
Rockwell type bond joints - 48 X 1000	
Thrust blocking and concrete capping 450 cu. yds. X 500/yd	225,000
Rock anchoring/grouted rebar 425 X 376/saddle	159,800
Grading, excavation 425 X 470/saddle	199,750
Installation of Penstock 18,900 X 16.60/ft	313,740
Rock excavation & placement at river crossings 29,116 cu. yds. X 16.50/yd.	480,414
Loose excavation & placement at river crossings 20,015 cu. yds. X 7.00/yd.	140,105
Backfill & placement of Penstock 4,100 X 26.71/ft	109,520
	$2,346,129
10% Engineering and Construction Mgt.	234,613
10% Contingency	234,613
Saddles & Pipeline - Misc Total	$2,815,355

HANALEI RIVER HYDROELECTRIC PROJECT

COST ESTIMATE (CONT)

Feeder Penstock

2000'- 22" X .188"	13 Max Q	$15.31 = 30,620
2000'- 26" X .188"	21	18.09 = 36,180
4200'- 26" X .188"	24	18.09 = 75,978
2200'- 20" X .188"	11	13.91 = 30,602
1900'- 16" X .188"	5	11.13 = 21,147
2900'- 20" X .188"	12	13.91 = 40,339
1400'- 24" X .188"	20	16.70 = 23,380
3800'- 22" X .188"	15	15.31 = 58,178
2500'- 20" X .188"	11	13.91 = 34,775
Shipping and Delivery		200,000
		$551,199
10% Engineering & Construction Mgt.		55,120
10% Contingency		55,120
TOTAL		**$661,439**

Feeder Penstock
Saddles & Pipeline - Misc.

Assume 30' spacing for 22,900' - 765 Saddles

For each saddle - assume and average of 1.0 cu. yds. conc. 765 X 1.0 X 600 $/yd. =	$ 459,000
Pipe straps, bolts etc. 765 X 200/Saddle	$ 153,000
Expansion joints - at 200' spacing = 115 joints Rockwell type bond joints - 115 X 450	$ 51,750
Thrust blocking	350,000
Rock anchoring, grouted rebar 765 X 450	344,250
Grading, excavation 765 X 300	229,500
Installation of Penstock 22,900 X 15/ft	343,500
Rock excavation at crossings 1634 cu. yds. X 16.50/yd	26,961
Loose excavation at crossings 1405 cu. yds. X 7.00/yd	9,835
	$1,967,796
10% Engineering and Construction Mgt.	196,780
10% Contingency	196,780
Saddles & Pipeline - Misc Total	**$2,361,356**

HANALEI RIVER HYDROELECTRIC PROJECT

COST ESTIMATE (CONT)

Feeder Diversions

24.5 yds. concrete/diversion X 9 = 220.5 yds. @ 600	$ 132,300
Trashracks, Anchors, Excavation and Rock Removal, Backfilling etc. 28,165 x 9	253,485
	$ 385,785
10% Engineering & Construction Mgt	38,579
10% Contingency	38,579
TOTAL	**$ 462,943**

Access Road

5,500 ft. @ $17.50/ft	$ 96,250
	$ 96,250
10% Engineering & Construction Mgt	9,625
10% Contingency	9,625
TOTAL	**$ 115,500**

Turbines and Generators

Two (2) vertical six jet, pelton type turbines	$1,441,261
Two (2) 7360 KVA, 6624 KW, 0.9 PF, 3/60/4160V,648 RPM overspeed, 80 degrees C rise over 40 degrees C ambient, class F insulated, open - DP with screens, vertical synchronous generators.	724,748
Switchgear lineup, ancillary equipment, transformer, substation, disconnect switch and other misc. items.	411,790
	$2,547,799
10% Installation, Engineering & Construction Mgt.	254,780
10% Contingency	254,780
Turbines and Generators Total	**$3,057,360**

HANALEI RIVER HYDROELECTRIC PROJECT

COST ESTIMATE (CONT)

Transmission Line

0.6 miles 69 KV overhead transmission line installed with wooden pole support features @ 120,000/mile	72,000
Installation of new substation including all necessary safety switches and equipment	331,680
	$403,680
10% Engineering & Construction Mgt	40,368
10% Contingency	40,368
Transmission Line Total	**$484,416**

Powerhouse and Tailrace

226 yds concrete for foundation & tailrace @ 400/yd	$ 90,400
Block and materials for exterior	89,177
Roof trusses, support structures and roofing material	84,483
Heating and ventilation	70,402
	$334,462
10% Engineering & Construction Mgt	33,446
10% Contingency	33,446
Powerhouse and Tailrace Total	**$401,354**

Stripping and Clearing

Stripping and clearing of vegetation in all areas used for construction, including disposal.	$110,560
10% Engineering & Construction Mgt	11,056
10% Contingency	11,056
Stripping and Clearing Total	**$132,672**

HANALEI RIVER HYDROELECTRIC PROJECT

SUMMARY OF VALUES

Diversion Structure	$ 301,693
Penstock	2,782,800
Saddles & Misc. Equipment	2,815,355
Feeder Penstock	661,439
Saddles & Misc. Equipment	2,361,356
Feeder Diversions	462,943
Access Road	115,500
Turbines & Generators	3,057,360
Transmission Line (including interconnection)	484,416
Powerhouse & Tailrace	401,354
Stripping & Clearing	132,672
SUBTOTAL	$13,576,888
Interest During Construction	407,306
TOTAL COST	$13,984,194

B-3c SOCIAL

All of the project's components are physically located far from population centers, and in fact would displace no people, or individual businesses or farms. No changes in existing income, employment or population distribution or composition are anticipated as a result of implementing the project. The quality of community life will be modestly affected, but the nature of that quality is believed to be related to recreational activities and aesthetic perception more than any other factors. There are few life, health and safety considerations. The likelihood of flash floods is miniscule both because of the design of the diversion weir (designed up to the Probable Maximum Flood) and because of the comparatively small amount of water impounded behind the barrier.

The quality of recreation may be adversely affected by the addition of an access road and above ground pipeline into the upper Hanalei Basin. However, the majority of these effects will be short term and the dense foilage will quickly re-establish itself in these areas which will minimize the long-term effects of the project.

The proposed project may adversely affect the quality of the fishing experience in the upper reaches of the Hanalei River. The intake structure will be screened in order to prevent entrainment of aquatic life into the pipeline. Further, a minimum by-pass flow will be incorporated into the project to preserve the existing aquatic habitat and riparian values.

B-3d ENVIRONMENTAL

The majority of the effects are related to construction impacts. Another consideration would be the aesthetic diminution of the Hanalei River resulting from the increased frequency of low flows. The acceptability of new man-made structures at or near a largely undeveloped site may also be a public concern. There are no endangered or threatened species affected in the project site. Also, there are no listed or nominated sites on the Historical Register of Historic Sites which would be disturbed from construction activities.

The Project would result in temporary increases in turbidity, both in the immediate project area and downstream during project construction. Concurrent short-term increases in sedimentation of stream habitat below the diversion could temporarily alter composition of the aquatic community in the affected area. Approximately 37.9 acres of State owned land would be disturbed during construction of the project from the diversion structure to the powerplant. The land would be re-vegetated subsequent to completion of the Project.

B-4 USE OF PUBLIC FUNDS OR LANDS FOR THIS ACTION

B-4a FUNDS

The use of public funds are not anticipated for the proposed hydroelectric facility. However, the public will have the opportunity to participate in the purchase of special purpose revenue bonds to finance the Hanalei Project which have been secured by the developer.

If bonding cannot be used for the Project, a private lending institution would likely supply the long-term financing. The equity portion of the financing would also come from private sources.

B-4b LANDS

All of the lands needed for the Project are owned by the State of Hawaii. No federally owned properties will be needed for the Project.

The lands needed for the proposed project are summarized in Tables B-4-1 and B-4-2. Figure B-4-3 illustrates the proposed project features with relaionship to the required lands.

TABLE B-4-1

HANALEI RIVER HYDROELECTRIC PROJECT

ACREAGE NEEDED FOR PROJECT COMPONENTS

DIVERSION STRUCTURE

A 200 ft x 200 ft easement will be needed for the diversion structure and associated equipment.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		0.9
				TOTAL ACREAGE		0.9 Acres

FEEDER DIVERSIONS

9-100 ft x 100 ft easements will be needed for the feeder diversions and associated equipment.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		2.1
				TOTAL ACREAGE		2.1 Acres

MAIN PENSTOCK

A 30-foot wide easement, 15 feet either side of centerline, approximately 23,325 feet long, running from the diversion structure to the powerhouse will be needed for the penstock.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		16.1
				TOTAL ACREAGE		16.1 Acres

TABLE B-4-1 (Cont.)

FEEDER PENSTOCKS

A 20 foot wide easement, 10 feet either side of centerline, approximately 22,900 feet long running from the feeder diversions to the main penstock.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		10.5
				TOTAL ACREAGE		10.5 Acres

POWERHOUSE

A 208.71 foot by 208.71 foot easement will be needed for the powerhouse and associated features.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		1.0
				TOTAL ACREAGE		1.0 Acres

TAILRACE

A 75 foot wide easement, 37.5 feet either side of centerline, approximately 300 feet long will be needed for the tailrace and associated features.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		0.5
				TOTAL ACREAGE		0.5 Acres

TABLE B-4-1 (Cont.)

TRANSMISSION LINE

A 50-foot wide easement, 25 feet either side of centerline, approximately 0.6 miles long, running from the powerhouse to the existing Kauai Electric System will be needed for the transmission line.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		3.6
				TOTAL ACREAGE		3.6 Acres

ACCESS ROADS

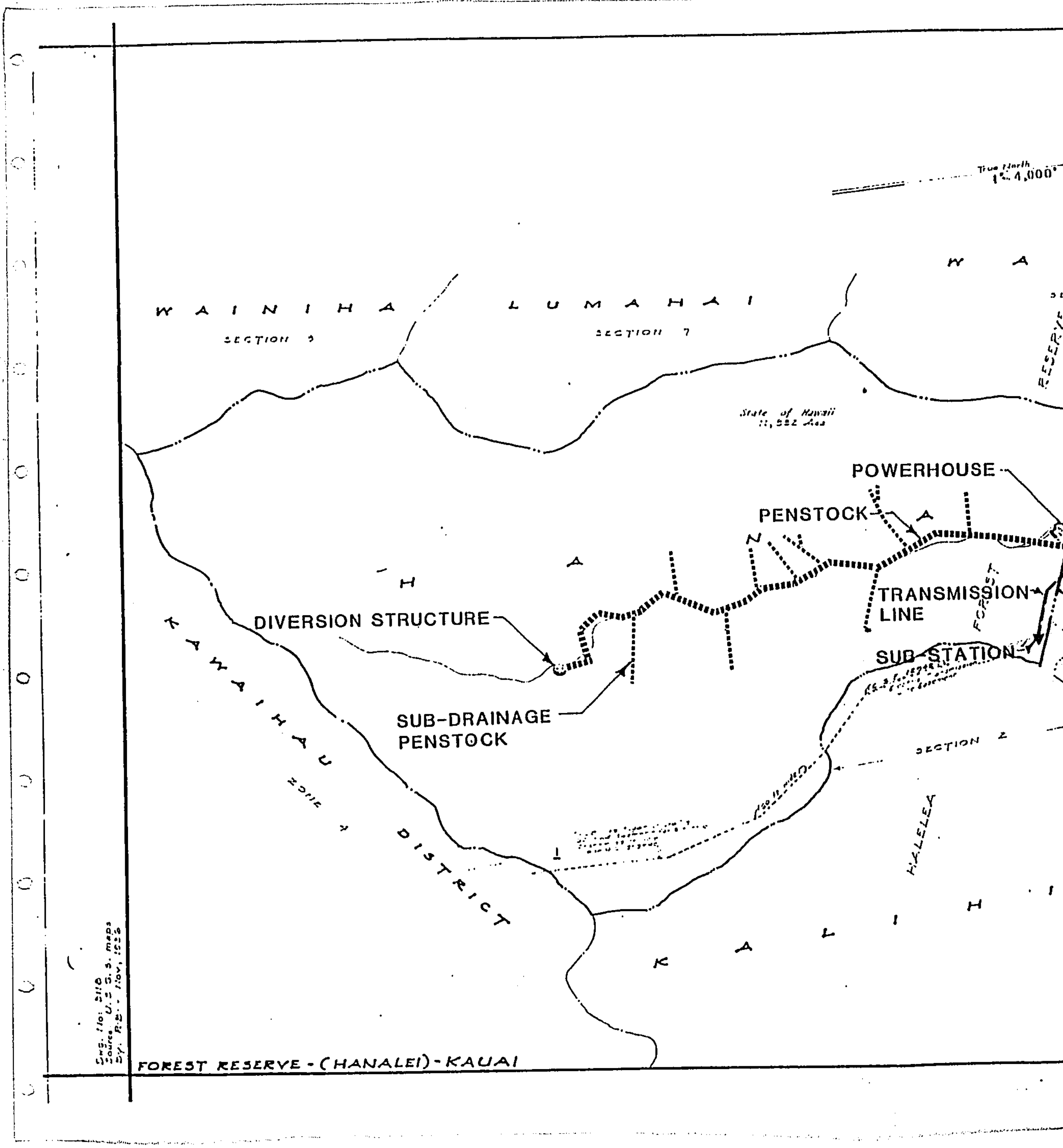
A 25 foot wide easement, 12.5 feet either side of centerline, approximately 5,500 feet long running from the existing road to the powerhouse.

ZONE	SECTION	PLAT	PARCEL	OWNER	LEASEE	ACREAGE
5	4	01		State		3.2
				TOTAL ACREAGE		3.2 Acres

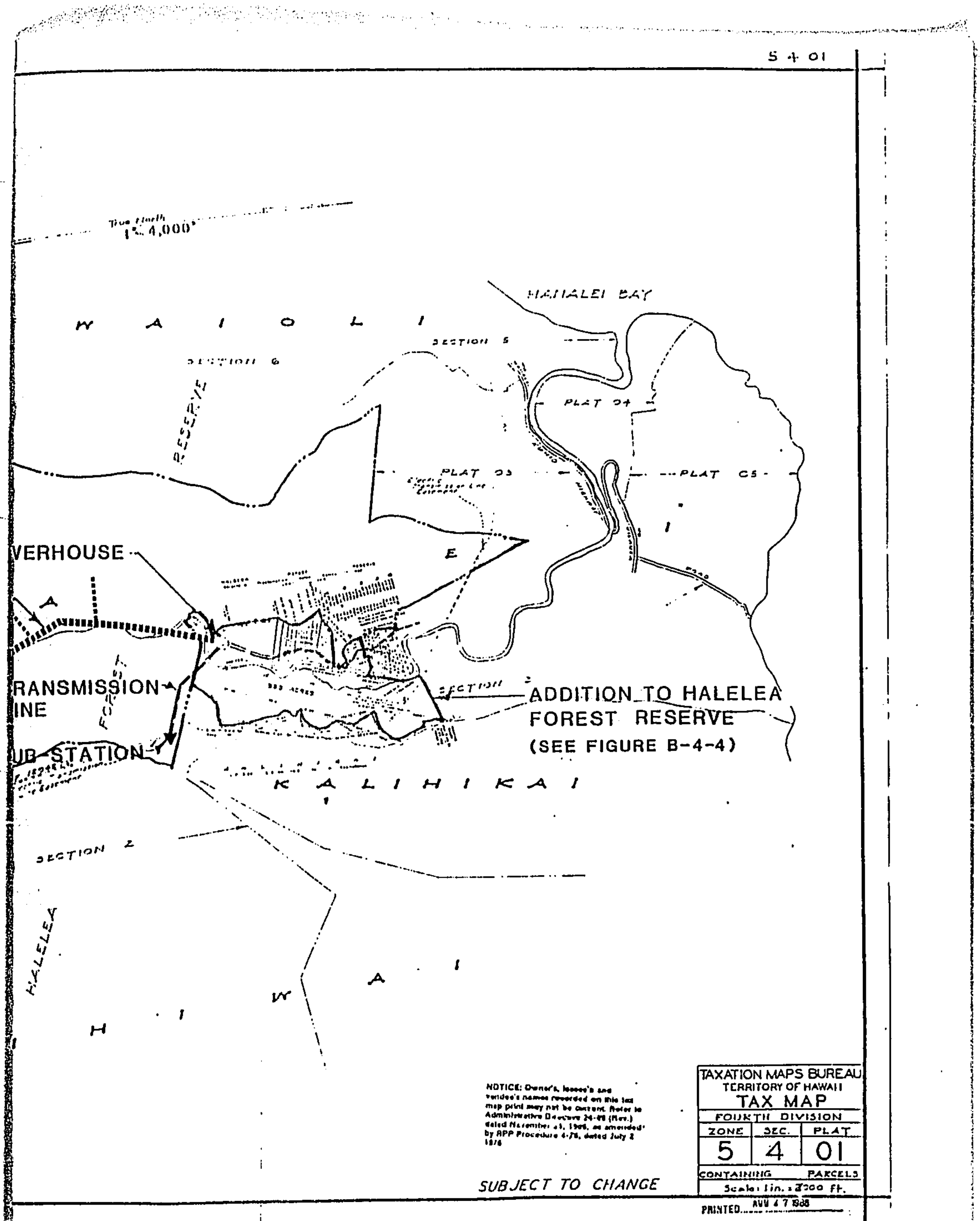
TABLE B-4-2

SUMMARY

OWNER	USE	ACREAGE
State of Hawaii	Conservation Lands	37.9
	TOTAL ACREAGE	37.9

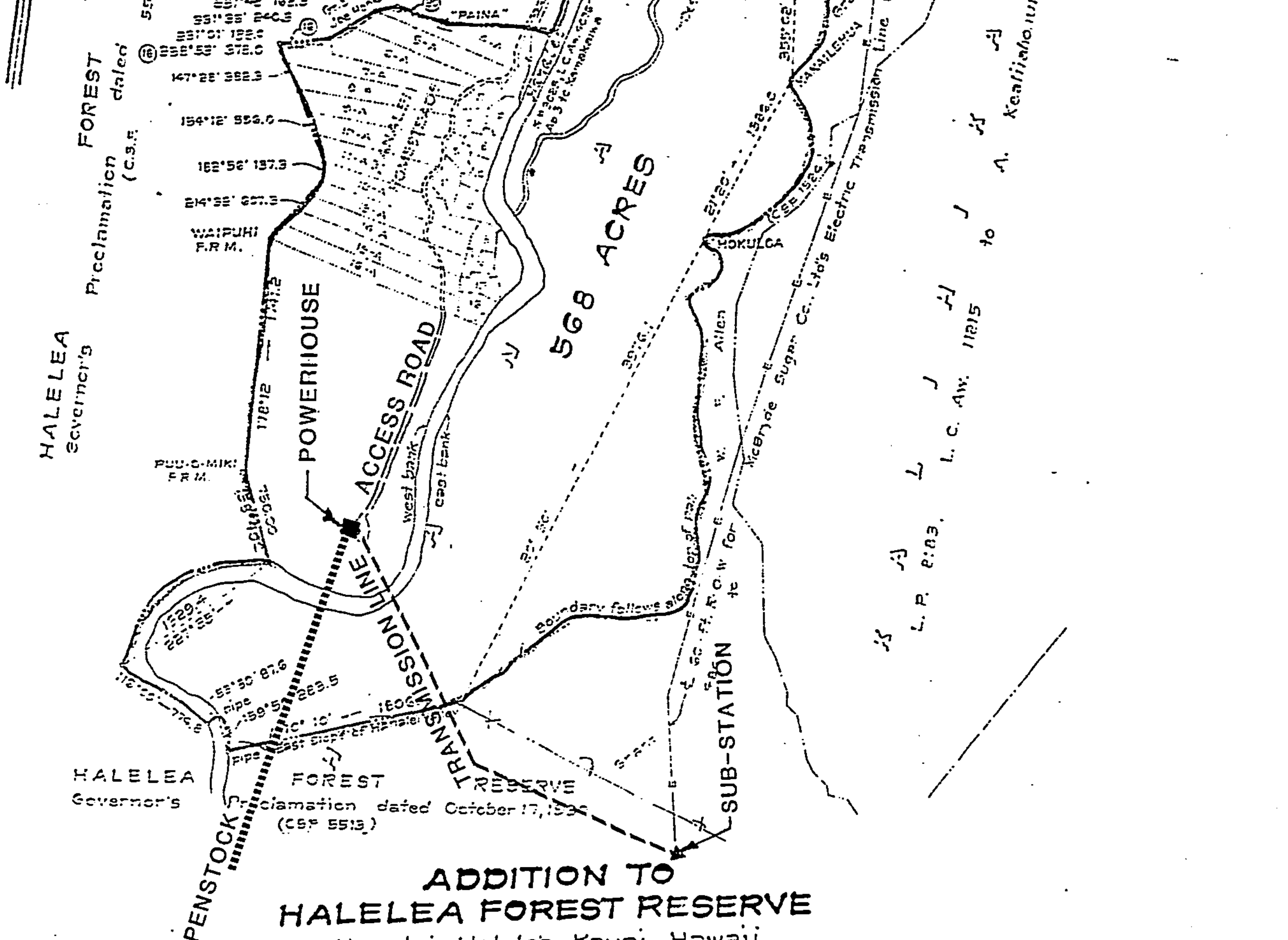


WAINIHA
LUMAHAI
SECTION 7
State of Hawaii
POWERHOUSE
PENSTOCK
TRANSMISSION LINE
DIVERSION STRUCTURE
SUB-DRAINAGE PENSTOCK
SUB-STATION
SECTION 2
KAWAIHAU DISTRICT
HALELEA
FOREST RESERVE - (HANALEI) - KAUAI



5 4 01
1" = 4,000'
HANALEI BAY
W A I O L I
SECTION 5
SECTION 6
RESERVE
PLAT 04
PLAT 03
PLAT 05
E
I
VERHOUSE
A
RANSMISSION
INE
FOREST
UB-STATION
SECTION
ADDITION TO HALELEA
FOREST RESERVE
(SEE FIGURE B-4-4)
K A L I H I K A I
SECTION 2
HALELEA
H I W A I
NOTICE: Owner's, lessee's and vendee's names recorded on this tax map print may not be current. Refer to Administrative Directive 24-68 (Rev.) dated November 1, 1968, as amended by RPP Procedure 4-78, dated July 2 1978
SUBJECT TO CHANGE
TAXATION MAPS BUREAU
TERRITORY OF HAWAII
TAX MAP
FOURTH DIVISION
ZONE
SEC.
PLAT
5
4
01
CONTAINING
PARCELS
Scale: 1in. = 2000 ft.
PRINTED AUG 4 7 1968

FIGURE B-4-2



ADDITION TO HALELEA FOREST RESERVE

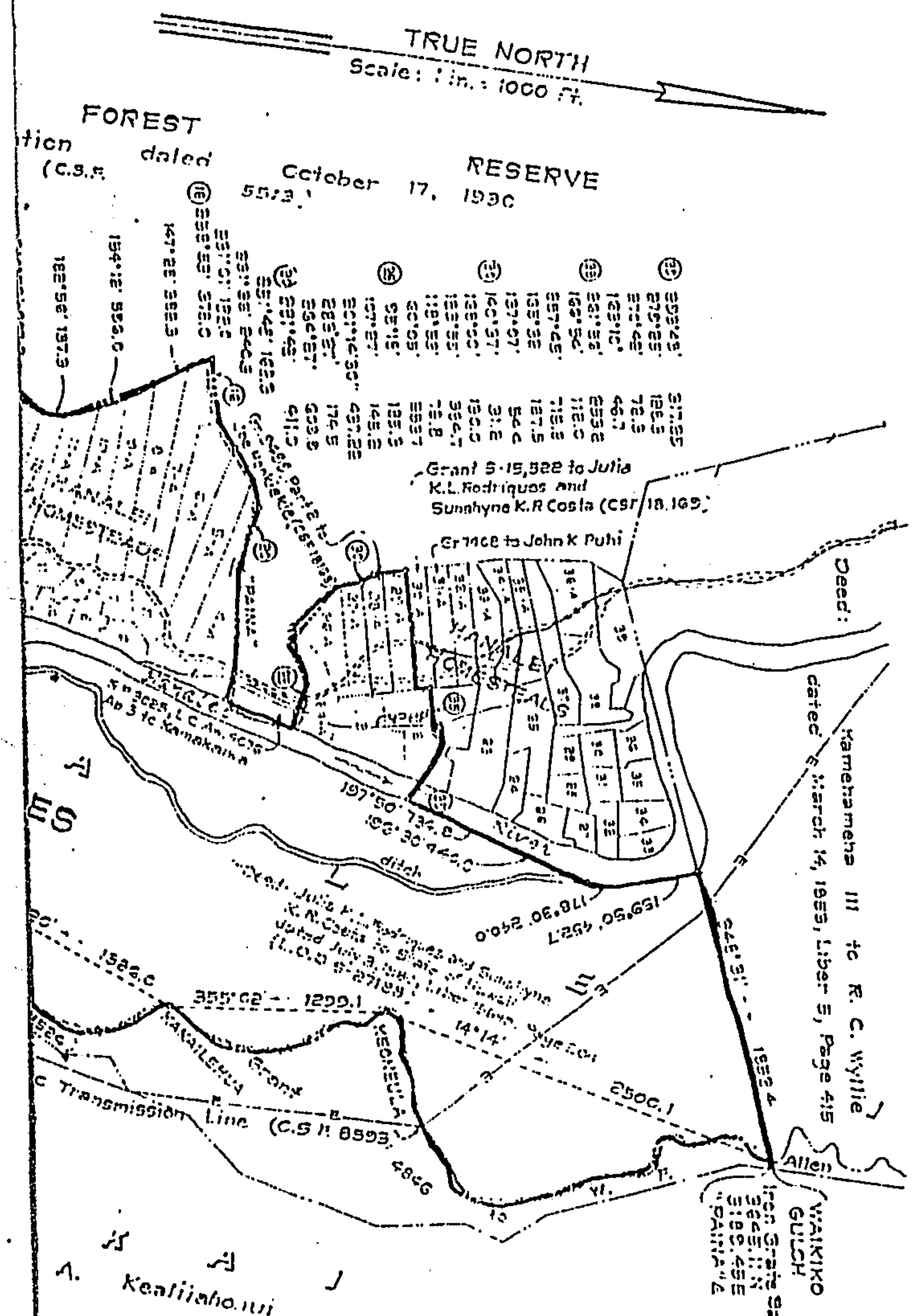
Hanalei, Halelea, Kauai, Hawaii

Scale : 1 inch = 1000 feet

EXHIBIT "B"

JOB K-263(8c)
C. BK 4, Page 149 (Sing)

TAX MAP: 5-3-01 5-4-02	SURVEY DIVISION DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES STATE OF HAWAII	
G & F. No 19838		R.S.S. Dec. 1, 1983



ADDITION TO HALELEA FOREST RESERVE

HANALEI HYDROELECTRIC PROJECT

FIGURE B-4-4

B-5 PHASING AND TIMING OF ACTION

B-5a DEVELOPMENT STEPS

The entire project, from initial planning to plant operation, is scheduled to proceed as follows:

1. Preliminary Planning -- This has been completed and is documented in this report.

2. Feasibility Study -- This phase includes preliminary engineering design, cost analysis, field studies, environmental analysis and applications for permits and approvals required to build the project. The products of this phase are a Feasibility Report, permit applications and an Environmental Impact Statement. This phase will conclude when the Final Environmental Impact Statement has been completed and the major required permits and approvals are obtained.

3. Design -- This phase includes preparing contract documents and specifications and ends when building and grading permits have been obtained and contracts are placed.

4. Financing -- This phase entails the completion of long-term financing agreements and the release of funds needed for construction of the Project.

5. Construction -- This phase involves the actual building of the Project. Plant operation marks the end of the construction phase.

The approximate schedule, by phase, for this project is depicted in Figure B-5-1.

PROJECT SCHEDULE

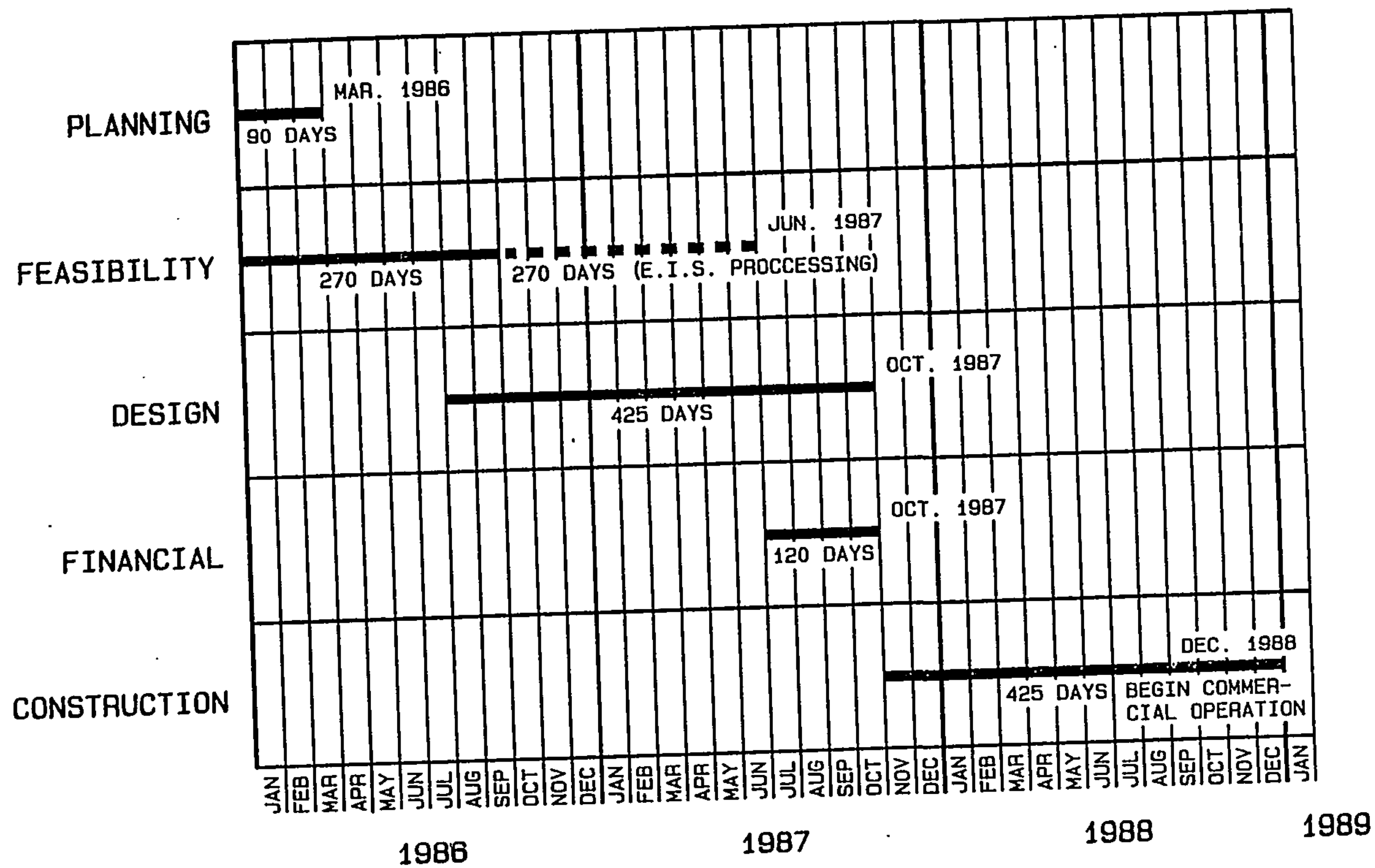


FIGURE b-5-1

B-6 SUMMARY OF TECHNICAL DATA

B-6a FUNCTIONAL ELEMENTS AND DESIGN DRAWINGS

B-6a FUNCTIONAL ELEMENTS AND DESIGN DRAWINGS

FUNCTIONAL ELEMENTS

The project would consist of diversion weirs, penstocks, a powerplant, a tailrace, a transmission line and access features. The main diversion weir, located approximately 11.1 river miles upstream of the mouth would be a gravity, overtopping type structure, about 10.0 feet high and a crest length of 75 feet. The structure would be designed to withstand overtoping by the Probable Maximum Flood.

The area ponded upstream would be less than 1 acre. As less than 1 acre-foot capacity would be provided, storage has not been considered for power diversion capability.

The major water conveyance feature would be an above ground 23,325 foot long steel penstock varying in size from 54 inches to 72 inches located near the bank of the river. The penstock would transport diverted flows from the diversion weir to the powerhouse. Other control and water conveyance structures along the transmission route are several feeder weirs and penstocks.

The powerplant would be sited at the base of the penstock and would encompass an area of approximately 2,520 square feet (63'x40'). Inside would be housed two indentical vertical pelton type water turbines. The dual turbine concept would allow operation over a wide range of flows. Due to the non-firm nature of discharges and the minimum discharge of 10 cfs required for turbine operation, the powerplant will be in operation approximately 60 percent of the time. Because of the 10 cfs conservation flow and the 10 cfs minimum operation flow, natural flows in the Hanalei River must exceed 20 cfs for operation under the current design. Needle valves would be provided to control inflow into the turbines. The generators would be of the vertical shaft synchronous type, directly connnected to the turbine. Additional electrical and mechanical equipment would be provided.

The powerhouse station would be unmanned and remotely controlled. The 69 kv powerline would be mounted on poles and would extend from the powerhouse to the existing Transmission line operated by Kauai Electric. The total length of the powerline would be 0.6 miles.

HANALEI HYDROELECTRIC POWER PROJECT

PERTINENT DATA

HYDROLOGIC AND HYDRAULIC

Drainage area of Hanalei River at diversion, sq. mi.		7.17
Mean annual flow (cfs)		70
Conservation discharge on main diversion (cfs)		10
Ponding storage volume (acre-ft)		0.6
Turbines: vertical Pelton units		
Net head, ft		480
Discharge range: Unit 1, cfs	10 to 119	
Unit 2, cfs	10 to 119	
Maximum diversion discharge, cfs		238

MAJOR CONSTRUCTION FEATURES

Diversion weir, height, ft.		10.0
crest length, ft.		75
Penstock,		
54-inch steel, length, ft.	4000	
56-inch steel, length, ft.	2300	
58-inch steel, length, ft.	2500	
62-inch steel, length, ft.	1800	
64-inch steel, length, ft.	2100	
66-inch steel, length, ft.	2200	
68-inch steel, length, ft.	1600	
70-inch steel, length, ft.	1400	
72-inch steel, length, ft.	5425	
Total Penstock Length		23,325
Powerline, 69 kv, length, mi		0.6
Powerplant		
Capacity, Unit 1, kw	4,000	
Unit 2, kw	4,000	
Total, kw		8,000
Average annual energy, million kwh		29.5

MECHANICAL AND ELECTRICAL

a. **The Powerhouse.** The powerhouse would be a conventional indoor plant constructed of reinforced concrete, housing two generating units with adquate space for maintenance and auxiliary equipment. Removal and servicing of powerplant equipment would be through hatches located in the powerhouse roof utilizing a mobile crane.

b. **Controls.** Control facilities would be for an unmanned plant, and protective devices would operate automatically to protect equipment without the need for operator assistance.

c. **Mechanical Equipment.** Station brake and governor air would be provided to the powerhouse by a single air compressor. Draft tube unwatering and drainage would be through a common sump using an automatic duplex pump system. Miscellaneous raw water systems would be supplied via a tap from the intake and boosted by pumps as necessary.

d. **Cooling System.** Powerhouse and generator would be cooled by using outside air. Generators would be cooled by drawing powerhouse air through the generator housing and discharging it directly outside. Powerhouse heating would not be required. Dehumidification would not be provided.

e. **Bulkheads and Valves.** The flow of water to the units would be through intake pipes fitted with hydraulically operated butterfly valves. Draft tube bulkhead installation and removal would be accomplished by a mobile crane.

f. **Turbines and Governors.** The installation of two "custom-built" vertical Pelton type turbines with butterfly valves would match the site's hydraulic conditions. The individual turbines selected are of indentical size and capacity. This would allow efficient operation over a wide variation of flow conditions.

g. **Generators and Excitation Systems.** The generators would be of the vertical shaft, synchronous type, with shaft directly connected to the turbine. The generators would be open ventilated with an 80-1/4 C rise, Class B insulation system without provisions for overload. The generators would have full run-away speed capability. The excitation systems would be specified to be the manufacturer's standard type. This can be either a direct connected brushless exciter or a bus-fed power potential source static excitation system. Solid-state continuously acting dynamic type voltage regulators would be used and would be incorporated in the unit switchgear.

h. **Generator Voltage System.** The connection between the generator and breaker would be with non segregated bus. The generator and station service breakers would be metal clad drawout type rated 250 MVA (nominal), 5 kV 1200 amps continuous. The breakers would be combined in a common switchgear lineup along with generator surge protections and instrument transformers.

i. **Station Service.** The station service power would be obtained via a tap, between the generator breaker and main power transformer. The station service transformer would be adjacent to the generator switchgear lineup. Station service power distribution would be a 480 volts 3-phase and 120/240 volts single phase.

j. **Transmission Line.** A 3-phase 69 kV overhead electrical transmission line would tie the power plant to the existing Kauai Electric System. The transmission line would be approximately 0.6 miles long.

k. **Unit Control and Protective Equipment.** A complete compliment of control and protective equipment would be provided on the Switchgear cubicles. Controls will provide for generator starting, stopping, and circuit breaker operation, including automatic synchronizing. Start and stop functions would be performed automatically as result of water level and frequency changes.

OPERATION AND MAINTENANCE

a. **Operation.** During normal operation the Powerhouse would be unmanned. The plant output would be monitored by the local utility and distributed through the existing power system.

b. **Maintenance.** A visual inspection and check of the plant, turbines, mechanical and electrical equipment would be required a minimum of 2 or 3 times a week.

POWER PRODUCTION

Tables B-6a-1 through B-6a-4 illustrate the potential monthly power generation of the Project based upon the combined daily flow data from the U.S.G.S. recording Station #16101000 on the Upper Hanalei River and Station #16103000 on the Lower Hanalei River. Minimum instream flow of 10 cfs was subtracted from flows used in the calculations.

Figures B-6a-1 through B-6a-8 illustrate the specific design details of the proposed project.

POWER PRODUCTION

MAXIMUM YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
STATION NUMBER 16103000 HANALEI RIVER NR HANALEI, KAUAI, HI STREAM SOURCE AGENCY USGS
LATITUDE 221131 LONGITUDE 1592757 DRAINAGE AREA 19.10 DATUM 35.80

MEAN DAILY ENERGY (GWH) ,WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN DAILY VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.0312	.1918	.1826	.0561	.0586	.1642	.1918	.0986	.0780	.1880	.1918	.1918
2	.0774	.1918	.1554	.0636	.0561	.1918	.1918	.0963	.0755	.1918	.1918	.1918
3	.1228	.1918	.1147	.0536	.0517	.1918	.1918	.0951	.0736	.1525	.1509	.1731
4	.1434	.1918	.0893	.0473	.0492	.1413	.1918	.0893	.0724	.1520	.1374	.1325
5	.0768	.1368	.0755	.0686	.0554	.1170	.1807	.0869	.0711	.1899	.1228	.1158
6	.0492	.1337	.0673	.1918	.0604	.1056	.1493	.0928	.0705	.1830	.1033	.1156
7	.0951	.0893	.1917	.1760	.0928	.1010	.1918	.1918	.0686	.1918	.1033	.0975
8	.0492	.0586	.0768	.0686	.0623	.0975	.1629	.1918	.0673	.1885	.0916	.0916
9	.0461	.0436	.0611	.0567	.0749	.1450	.1918	.1355	.0673	.1750	.0881	.0843
10	.0350	.0387	.0561	.0579	.1736	.1580	.1337	.1170	.0661	.1301	.1246	.0916
11	.0312	.0399	.0586	.0611	.1918	.1918	.1158	.1678	.0724	.1124	.1698	.1918
12	.0280	.0436	.0567	.0724	.1068	.1918	.1252	.1554	.0686	.1102	.1876	.1839
13	.0793	.0486	.0480	.0492	.0673	.1918	.1918	.1192	.0711	.1918	.0998	.1755
14	.0374	.0461	.0473	.0461	.0554	.1918	.1593	.1113	.0705	.1698	.0893	.1918
15	.0293	.0837	.0449	.0430	.0511	.1918	.1252	.1033	.0661	.1607	.1102	.1746
16	.0261	.0667	.0424	.0623	.0492	.1918	.1918	.0986	.1567	.1918	.1918	.1158
17	.0337	.0648	.0399	.0887	.0461	.1477	.1918	.1620	.1580	.1918	.1918	.0998
18	.0381	.1918	.0381	.0586	.0442	.1918	.1899	.1918	.0975	.1918	.1918	.0986
19	.0261	.1039	.1056	.1688	.0554	.1918	.1313	.1313	.0928	.1862	.1313	.0869
20	.0229	.0673	.1918	.1918	.1918	.1918	.1918	.1170	.1079	.1413	.1090	.0806
21	.0210	.0598	.1918	.1918	.1918	.1918	.1918	.1252	.1068	.1918	.1807	.0755
22	.0210	.0542	.1918	.1803	.1918	.1918	.1769	.1045	.0793	.1918	.1918	.0711
23	.0405	.1918	.1918	.1192	.1918	.1918	.1493	.1010	.0724	.1918	.1918	.0755
24	.1807	.1918	.1918	.1683	.1918	.1918	.1541	.1664	.0736	.1880	.1918	.0724
25	.0424	.1894	.1918	.1918	.1918	.1918	.1368	.1113	.1276	.1355	.1918	.0940
26	.0561	.1917	.1750	.1010	.1918	.1817	.1158	.1033	.1380	.1102	.1918	.1170
27	.1918	.1918	.1228	.1010	.1918	.1918	.1079	.0975	.1313	.1215	.1693	.1136
28	.1918	.1434	.1056	.0951	.1899	.1918	.1698	.0893	.1090	.1090	.1567	.1509
29	.1918	.1624	.0818	.0780	.0000	.1918	.1158	.0869	.1839	.1240	.1493	.0843
30	.1731	.1918	.0698	.0711	.0000	.1918	.1068	.0916	.1918	.1477	.1567	.0998
31	.1141	.0000	.0623	.0630	.0000	.1918	.0000	.0806	.0000	.1068	.1918	.0000
TOTAL	2.3025	3.5924	3.3199	3.0427	3.1266	5.3867	4.8162	3.7103	2.8856	5.0083	4.7414	3.6290
MEAN	.0743	.1197	.1071	.0982	.1117	.1738	.1605	.1197	.0962	.1616	.1529	.1210
MAX	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
MIN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

WTR YR 1982 TOTAL 45.5616 MEAN .1247 MAX .0000 MIN .0000

TABLE B-6a-1

POWER PRODUCTION

MINIMUM YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
HANALEI RIVER NR HANALEI, KAUAI, HI

STATION NUMBER 16103000   STREAM   SOURCE AGENCY US 3B
LATITUDE 221131   LONGITUDE 1592757   DRAINAGE AREA 19.10   DATUM 35.80

MEAN DAILY ENERGY (GWH) ,WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984
MEAN DAILY VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.1918	.0480	.0286	.0223	.1319	.0248	.0969	.0467	.0305	.0280	.0185	.0134
2	.0998	.0473	.0280	.0217	.1102	.0411	.0399	.0424	.0299	.0267	.0185	.0134
3	.1033	.0467	.0274	.0217	.0536	.0261	.0337	.0436	.0299	.0274	.0198	.0128
4	.0869	.0399	.0274	.0405	.0430	.0280	.0293	.0387	.0293	.0299	.0350	.0121
5	.0755	.0374	.0267	.1107	.0399	.0242	.0274	.0337	.0286	.0293	.0236	.0121
6	.0648	.0350	.0261	.0424	.0381	.0236	.0424	.0324	.0286	.0248	.0191	.0121
7	.0648	.0337	.0261	.0286	.0461	.0236	.0561	.0312	.0274	.0236	.0185	.0153
8	.1549	.0324	.0255	.0255	.0881	.0229	.0436	.0318	.0274	.0236	.0172	.0134
9	.0698	.0305	.0255	.0236	.0486	.0217	.1276	.0312	.0312	.0236	.0172	.0204
10	.1276	.0299	.0261	.0236	.0368	.0210	.1862	.0280	.0350	.1423	.0210	.0166
11	.0698	.0324	.0261	.0223	.0337	.0236	.1918	.0261	.0461	.0523	.0185	.0210
12	.0542	.0661	.0261	.0318	.0318	.0424	.1090	.0261	.1130	.0312	.0223	.0166
13	.1150	.1325	.0312	.0511	.0293	.0229	.1918	.0255	.0774	.0274	.0381	.0134
14	.0724	.0467	.0261	.0350	.0411	.0210	.1918	.0248	.0381	.0248	.0248	.0128
15	.0642	.0350	.0248	.0261	.0498	.0204	.0780	.0261	.0381	.0242	.0191	.0147
16	.0467	.0312	.0242	.0236	.0705	.0198	.0604	.0255	.0899	.0242	.0185	.0153
17	.0579	.0299	.0236	.0793	.0504	.0191	.0667	.0261	.1423	.0242	.0236	.0134
18	.0449	.0286	.0517	.0542	.0362	.0191	.0905	.0418	.0461	.0248	.0210	.0617
19	.1817	.1004	.0480	.0381	.0350	.0261	.0869	.0261	.0337	.0223	.0185	.0293
20	.1918	.1221	.0261	.0305	.0411	.0223	.1141	.0324	.0305	.0242	.0185	.0153
21	.1554	.0922	.0261	.0274	.0399	.0198	.1319	.0261	.0312	.0236	.0172	.0134
22	.0951	.0567	.0255	.0261	.0318	.0198	.0862	.0293	.0299	.0236	.0166	.0160
23	.0793	.0430	.0236	.0579	.0318	.0204	.1187	.0337	.0312	.0229	.0843	.0166
24	.0630	.0393	.0236	.1793	.0286	.0172	.0793	.1130	.0324	.0229	.0617	.0121
25	.0579	.0424	.0280	.0711	.0274	.0166	.0561	.0486	.0305	.0210	.0299	.0179
26	.1717	.0350	.0242	.0812	.0280	.0166	.1198	.0424	.0337	.0210	.0498	.1620
27	.1085	.0324	.0229	.0579	.0299	.0204	.1918	.0393	.0312	.0236	.0223	.0381
28	.0648	.0312	.0229	.0517	.0280	.0286	.0928	.0362	.0299	.0210	.0204	.0236
29	.0561	.0318	.0229	.0461	.0255	.1147	.0648	.0356	.0286	.0191	.0198	.0223
30	.0586	.0299	.0223	.0686	.0000	.0561	.0542	.0337	.0286	.0185	.0185	.0198
31	.0498	.0000	.0223	.0730	.0000	.0393	.0000	.0312	.0000	.0185	.0160	.0000
TOTAL	2.8988	1.4396	.8392	1.4926	1.3259	.8630	2.8596	1.1090	1.2600	.8943	.7876	.6966
MEAN	.0935	.0480	.0271	.0481	.0457	.0278	.0953	.0358	.0420	.0288	.0254	.0232
MAX	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
MIN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

WTR YR 1984 TOTAL 16.4663 MEAN .0451 MAX .0000 MIN .0000

TABLE B-6a-2

POWER PRODUCTION

MEDIAN YEAR

BINGHAM ENGINEERING HYDROLOGY DIVISION
STATION NUMBER 16103000 HANALEI RIVER NR HANALEI, KAUAI, HI STREAM SOURCE AGENCY USGS
LATITUDE 221131 LONGITUDE 1592757 DRAINAGE AREA 19.10 DATUM 35.80

MEAN DAILY ENERGY (GWH) ,WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968
,MEAN DAILY VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.0393	.0473	.1918	.0940	.0567	.0399	.0837	.1918	.0324	.0711	.1918	.0381
2	.0910	.0957	.1918	.1445	.0567	.0374	.0648	.1620	.0324	.0461	.0981	.0523
3	.0467	.1461	.1918	.1187	.0567	.0362	.0523	.1096	.0324	.0374	.0630	.0318
4	.0511	.0473	.1693	.1192	.0611	.0350	.0461	.1760	.0461	.0374	.0517	.0248
5	.0424	.0399	.1620	.1918	.0586	.0399	.1530	.1633	.0374	.0418	.0436	.0229
6	.0356	.0561	.1571	.1589	.0523	.0362	.0399	.1021	.0436	.0324	.0.30	.0223
7	.0617	.0381	.1085	.0934	.0523	.0350	.0337	.0899	.0399	.0305	.0393	.0248
8	.0667	.0442	.1918	.0755	.0523	.0337	.0424	.0824	.0648	.0293	.0381	.0261
9	.0517	.0356	.1918	.0648	.0523	.0337	.1807	.0768	.0523	.0280	.0548	.1918
10	.0473	.0511	.1918	.0579	.0523	.0837	.1918	.1181	.0461	.0293	.0511	.0862
11	.0511	.0436	.1918	.0542	.0523	.0957	.0957	.1153	.0586	.0774	.0486	.0362
12	.0467	.0374	.1153	.0536	.0837	.1918	.0711	.0768	.0711	.1423	.0399	.0305
13	.0442	.0337	.0787	.0492	.0293	.1664	.0899	.0686	.0899	.0899	.0655	.0405
14	.0411	.0299	.0724	.0455	.0293	.1899	.0648	.0648	.1016	.0774	.0368	.0305
15	.0374	.0274	.0498	.0492	.0548	.1387	.1130	.0611	.0399	.0461	.0411	.0274
16	.0356	.0248	.1355	.1918	.0286	.1918	.0945	.0598	.0523	.0411	.0337	.0267
17	.0337	.0299	.1918	.0951	.0261	.1918	.0711	.0517	.0374	.1918	.0343	.0255
18	.0343	.0274	.1664	.0573	.0261	.1130	.0579	.0492	.0399	.0837	.0350	.0248
19	.1461	.0837	.1096	.0498	.0261	.0957	.1918	.0467	.0424	.0523	.0286	.0393
20	.1726	.1130	.0875	.0461	.1423	.0837	.1918	.0467	.0368	.0837	.0274	.0248
21	.1010	.0523	.0755	.0536	.1918	.0711	.1466	.0492	.0523	.0561	.0480	.0261
22	.0598	.0899	.0680	.0673	.1130	.0837	.1844	.0455	.0461	.0517	.0724	.0229
23	.1124	.1918	.1918	.0461	.0523	.1918	.1488	.0436	.0523	.1918	.0305	.0255
24	.0598	.1918	.1918	.0399	.0399	.1918	.1918	.0418	.0461	.1418	.0274	.0910
25	.0368	.1918	.1386	.0387	.0461	.1918	.1918	.0411	.0337	.0743	.0554	.0511
26	.0331	.1918	.0850	.0368	.0436	.1423	.1871	.0411	.0374	.0561	.0393	.1295
27	.0343	.1918	.0724	.1918	.0399	.1016	.1917	.0399	.0461	.0461	.0381	.0711
28	.0374	.1918	.0774	.1270	.0411	.0837	.1918	.0424	.0837	.0411	.0299	.0350
29	.0467	.1918	.0850	.0698	.0424	.1664	.1624	.0430	.0399	.0393	.0274	.0305
30	.1482	.1918	.0598	.0579	.0000	.1918	.1769	.0374	.1918	.0393	.0267	.0274
31	.0611	.0000	.1918	.0548	.0000	.1130	.0000	.0343	.0000	.1918	.0267	.0000
TOTAL	1.9071	2.7287	4.1833	2.5943	1.6599	3.3901	3.7035	2.3721	1.6269	2.1983	1.4919	1.3374
MEAN	.0615	.0910	.1349	.0837	.0572	.1094	.1235	.0765	.0542	.0709	.0481	.0446
MAX	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
MIN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

WTR YR 1968 TOTAL 29.1936 MEAN .0796 MAX .0000 MIN .0000

TABLE B-6a-3

POWER PRODUCTION AVERAGE

BINGHAM ENGINEERING HYDROLOGY DIVISION

SUMMARY TABLE

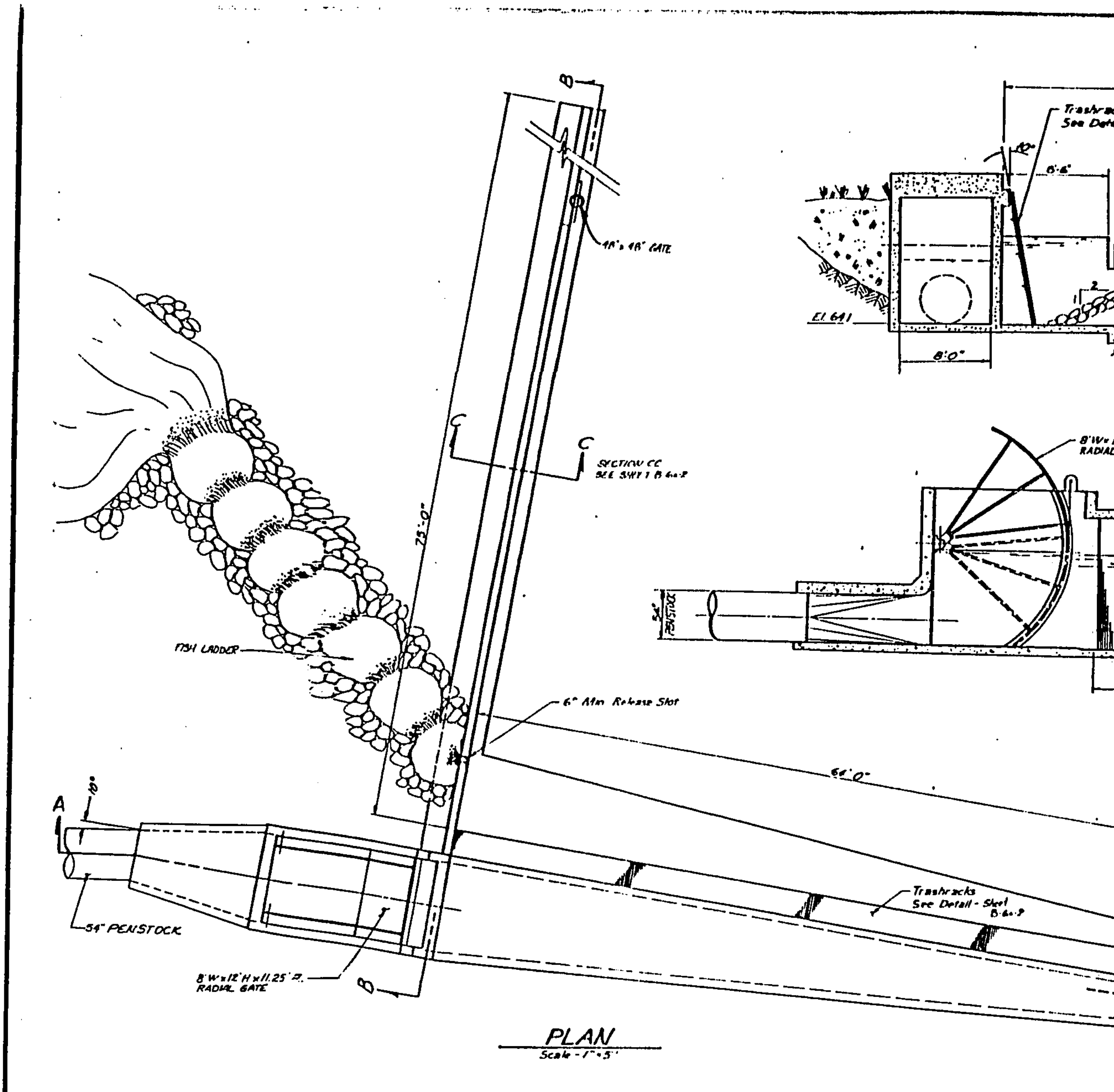
MEAN MONTHLY ENERGY (GWH)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1964	2.3914	1.0585	.9584	2.8530	2.7231	4.4532	3.4155	3.2735	1.5072	3.5900	2.4038	2.3047	30.9323
1965	3.7209	4.8578	4.0010	3.5537	2.6280	2.1728	4.3317	3.9870	3.5918	3.3200	2.4608	1.7686	40.5941
1966	3.7139	5.0228	4.6782	2.9395	3.5196	1.6836	1.1273	1.1282	.9417	1.8764	2.6126	1.0544	30.2983
1967	2.1608	3.1895	3.1498	3.1634	2.8748	3.3601	3.3813	2.9383	1.3894	1.9372	2.9856	1.6579	32.1882
1968	1.9071	2.7287	4.1833	2.5943	1.6599	3.3901	3.7035	2.3721	1.6269	2.1983	1.4919	1.3374	29.1936
1969	2.2343	1.9278	3.9926	2.6859	4.0182	3.5448	2.9805	3.1169	1.5495	3.6037	1.8581	2.6103	34.1226
1970	1.8563	2.1853	2.4210	2.8937	.9043	.7777	3.6703	2.0736	1.1799	2.2504	1.5676	1.7462	23.5263
1971	1.4943	3.5140	4.0617	2.8717	2.2803	4.1059	4.6656	2.3007	1.2306	1.4064	.8669	1.2486	30.0388
1972	1.4302	2.0823	3.6390	2.9707	3.8025	2.0732	3.4084	1.8807	1.5860	2.7359	1.3743	1.3254	28.3086
1973	2.1283	2.7734	1.1775	1.5945	2.1022	4.0337	2.3608	3.5449	1.5443	1.1773	.4960	.6423	23.5754
1974	1.4517	3.2915	2.5980	2.7906	2.6099	3.9839	5.0448	4.6574	3.3166	3.4033	2.3007	2.6795	38.1278
1975	1.7070	3.4844	2.5977	4.3455	3.0164	2.8131	2.9592	1.6446	.7727	.9785	.7142	.3585	25.3916
1976	.8700	1.8577	1.3080	2.7337	2.4573	4.0543	4.9249	2.4441	1.4392	1.9126	1.5206	.9606	26.4830
1977	1.7611	1.2898	.9108	.8897	2.0266	4.1902	2.8346	2.6500	1.9933	2.0159	1.5588	.7958	22.9167
1978	1.3469	2.1115	1.7192	.9407	.4605	1.3159	2.8378	2.8327	4.3593	3.0861	3.6300	2.2934	26.9339
1979	1.7605	3.0451	2.7770	3.4796	4.4016	1.8449	1.4586	2.3663	2.5882	1.3058	1.1521	.6707	26.8505
1980	1.0334	2.3518	1.8430	1.4960	.7535	4.2210	4.3757	4.2658	3.5234	4.4407	1.9943	2.3704	32.6891
1981	2.9096	2.0158	1.7676	1.0821	2.4469	2.2697	3.5904	2.2364	1.2414	2.8443	2.5641	1.1821	26.1704
1982	2.3025	3.5924	3.3199	3.0427	3.1266	5.3867	4.8162	3.7103	2.8856	5.0083	4.7414	3.6290	45.5616
1983	3.9075	4.0109	3.5894	2.5169	1.1838	1.0353	2.3388	2.5927	1.3731	2.8041	2.9715	1.9161	30.2400
1984	2.8988	1.4396	.8392	1.4926	1.3259	.8630	2.8596	1.1090	1.2600	.8943	.7876	.6966	16.4663

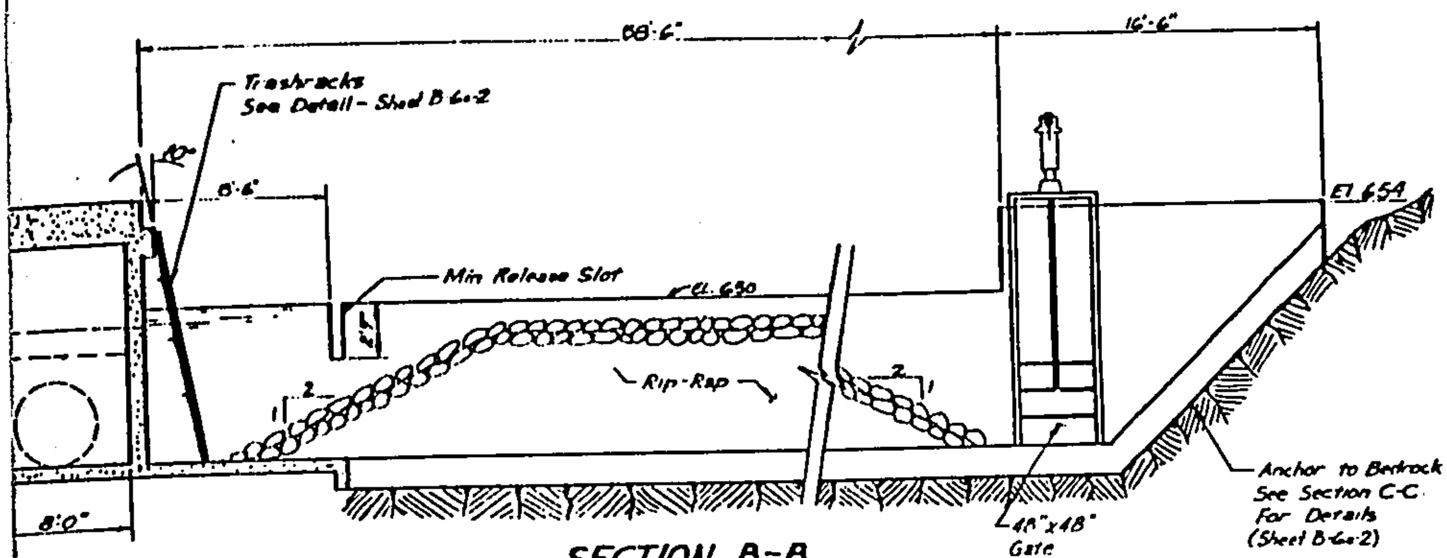
AVERAGE MONTHLY ENERGY (GWH)

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
2.1422	2.7538	2.6444	2.5205	2.4058	2.9330	3.3850	2.7212	1.9476	2.5138	2.0025	1.5829	29.5528

TABLE B-6a-4



PLAN
Scale - 1" = 5'



SECTION B-B
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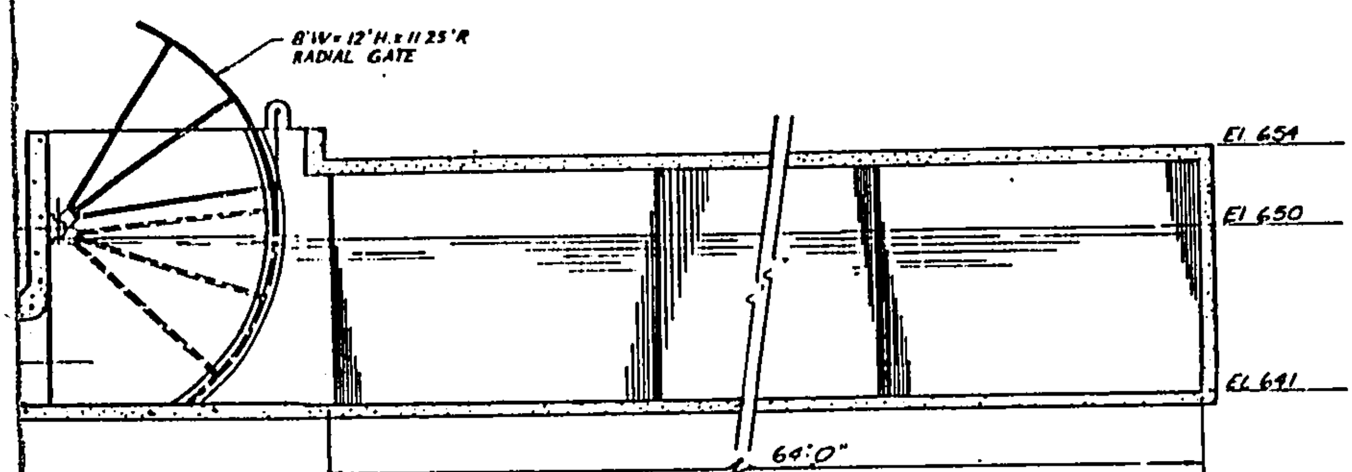

SECTION A-A
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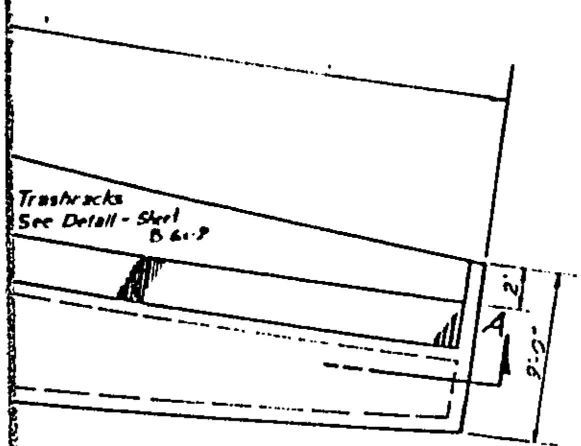
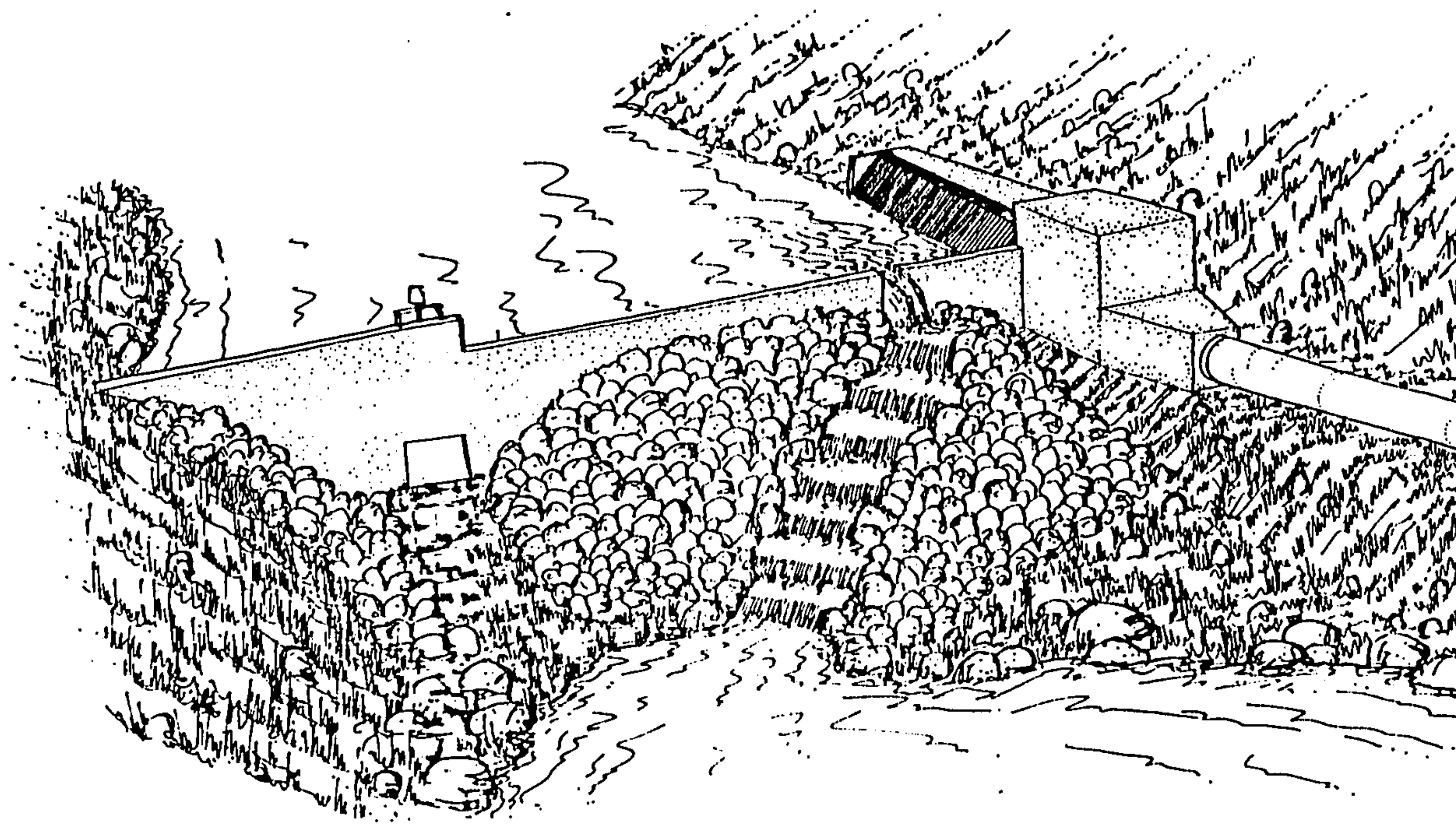


HANALEI HYDROELECTRIC PROJECT

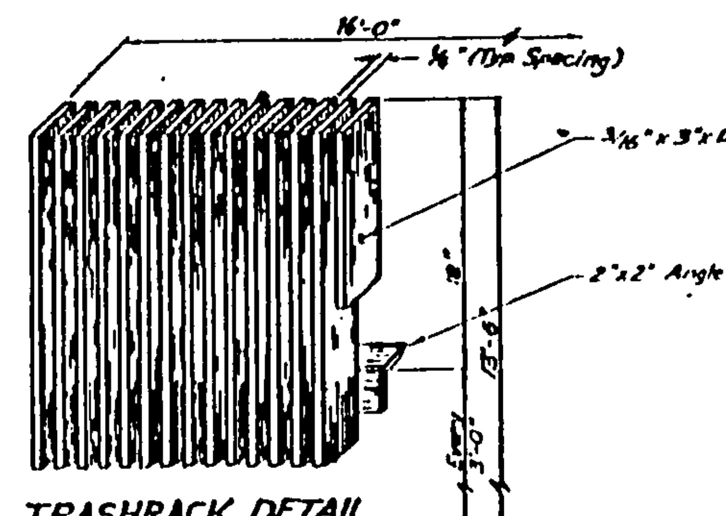
MAIN DIVERSION WEIR
INTAKE STRUCTURE

BINGHAM ENGINEERING

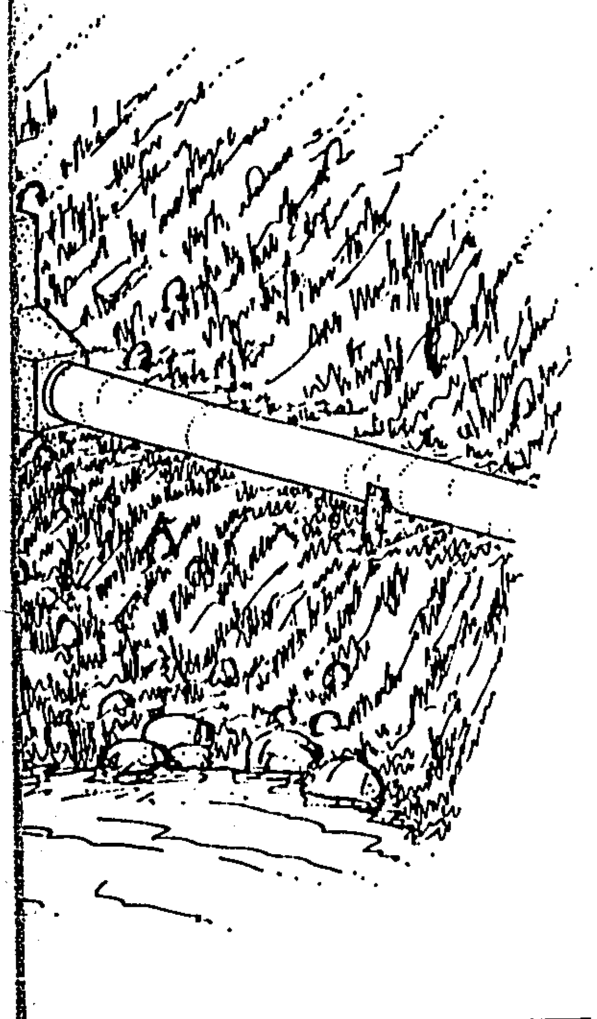
JAN 1987 | 609-014 | B-6a-1

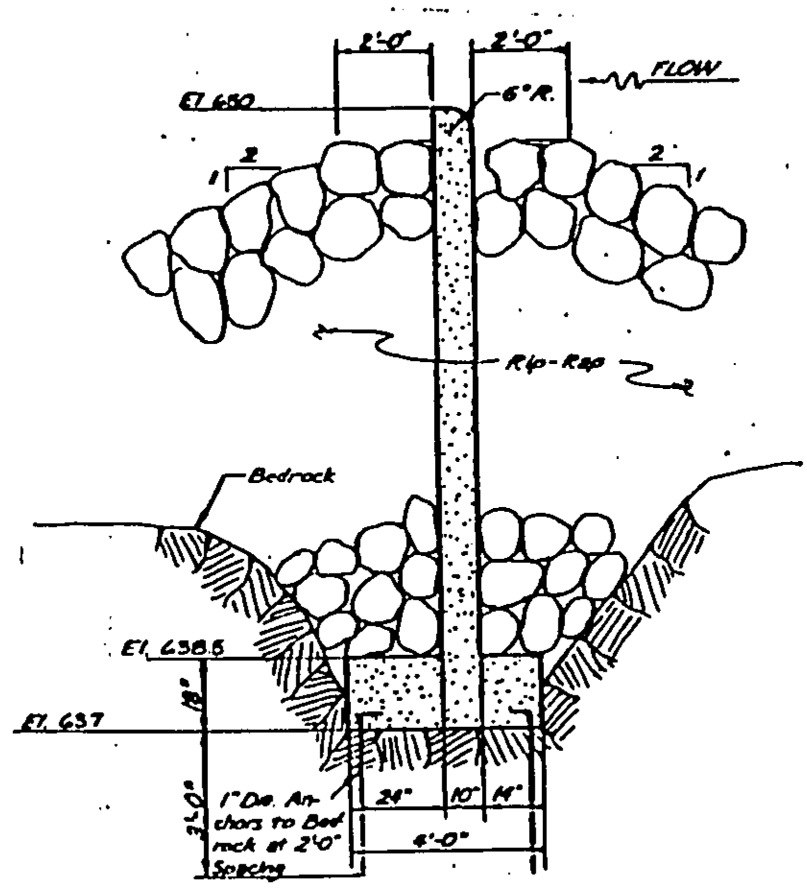


PERSPECTIVE SKETCH OF FISH LADDER
N.T.S.

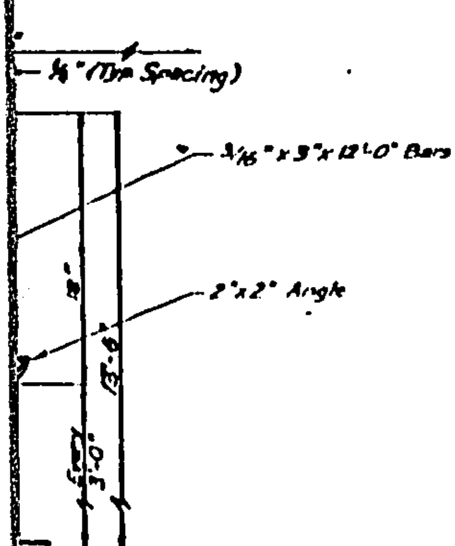


TRASHRACK DETAIL
N.T.S.





SECTION C-C
Scale- 1"=2'

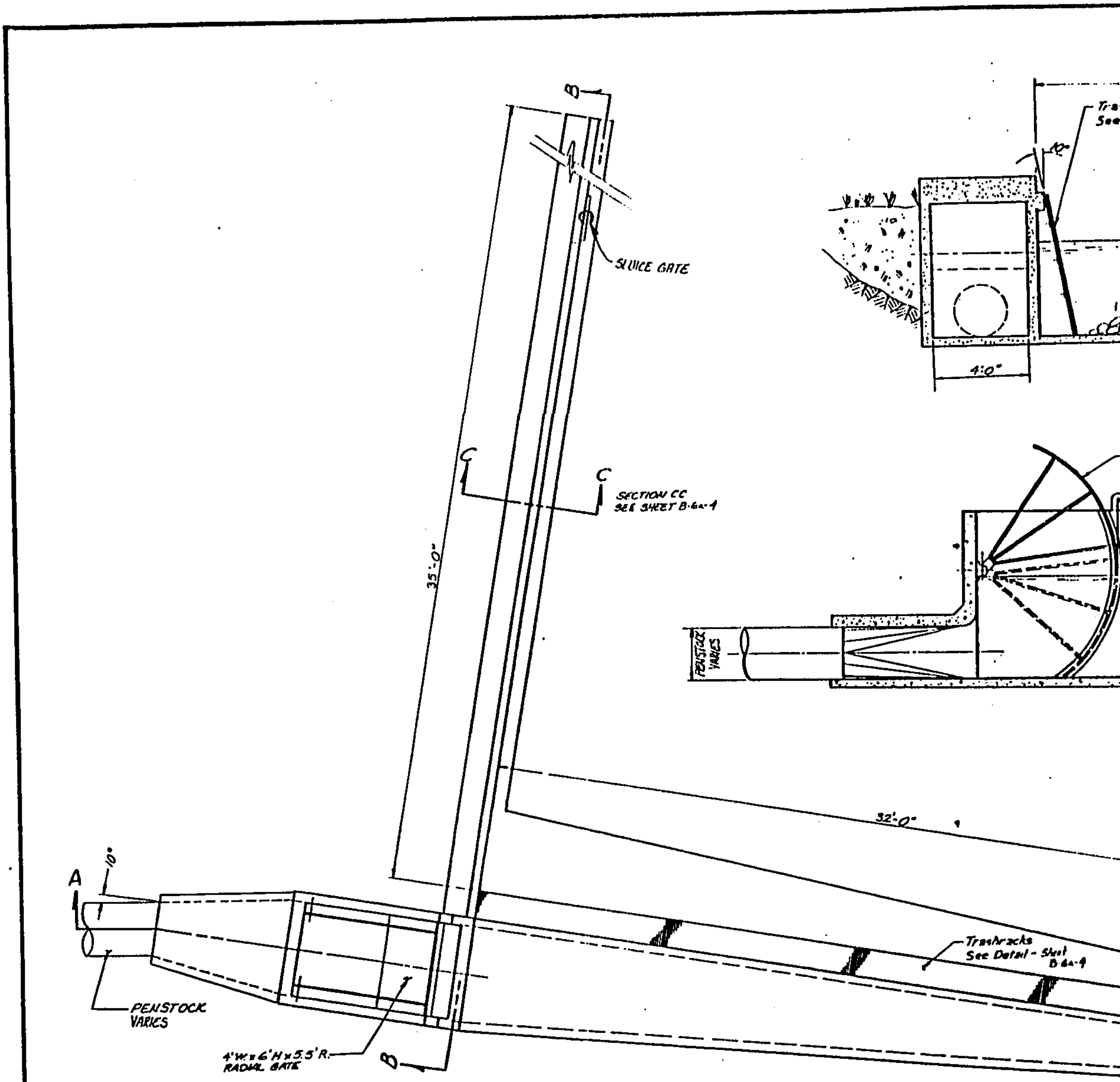


HANALEI HYDROELECTRIC PROJECT

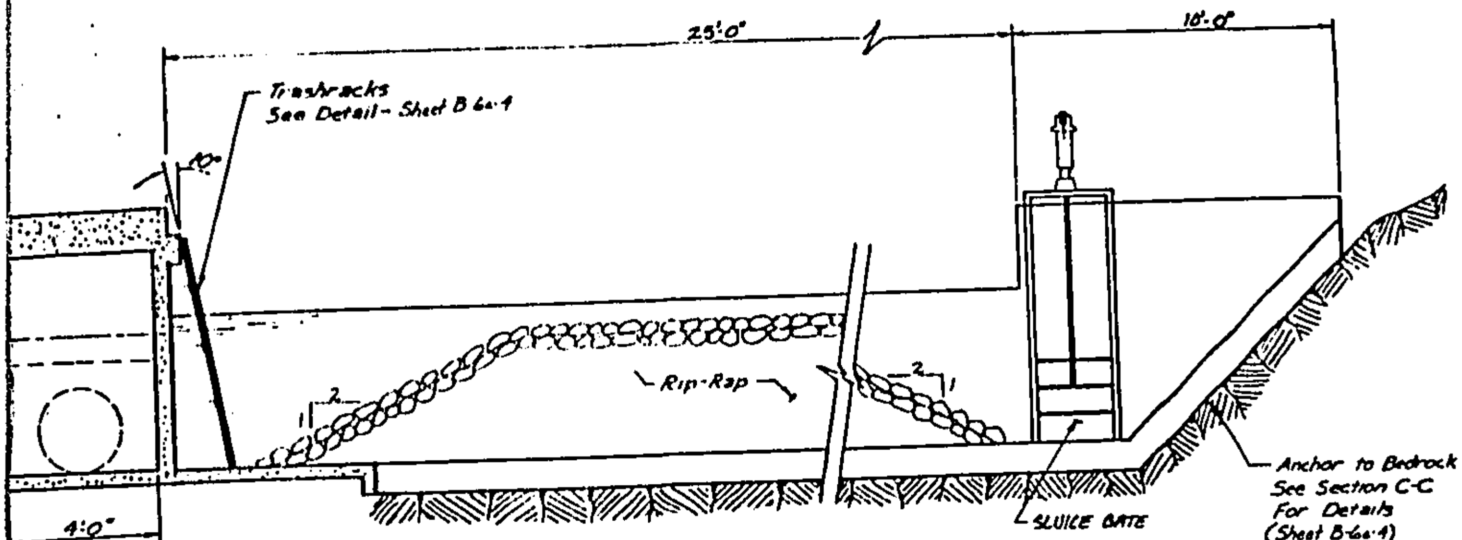
MAIN DIVERSION WEIR
INTAKE STRUCTURE DETAILS
AND FISH LADDER

BINGHAM ENGINEERING

Date JAN 1987 | Project # 609-014 | Dwg. B-6a-2



PLAN
NOT TO SCALE



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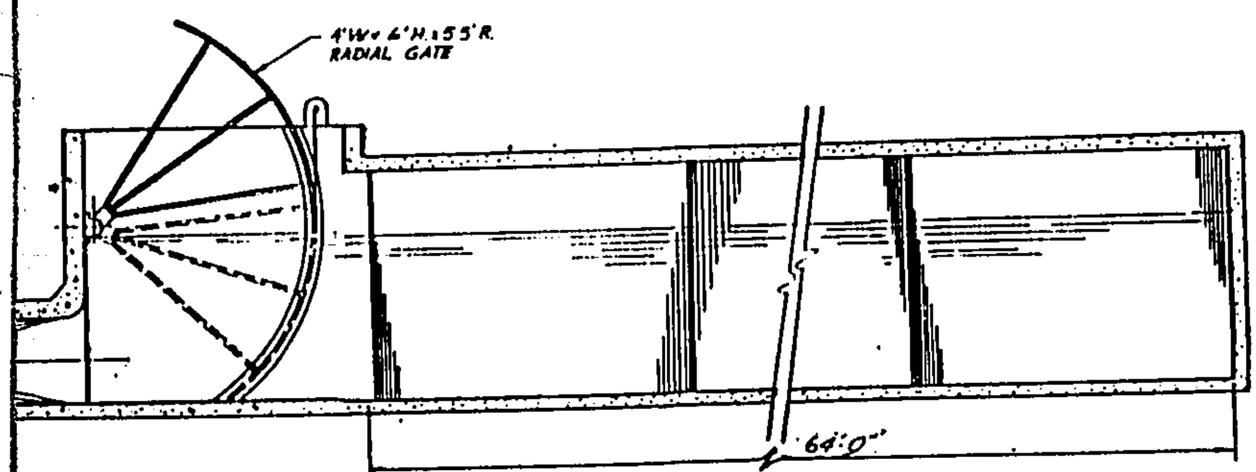

SECTION A-A
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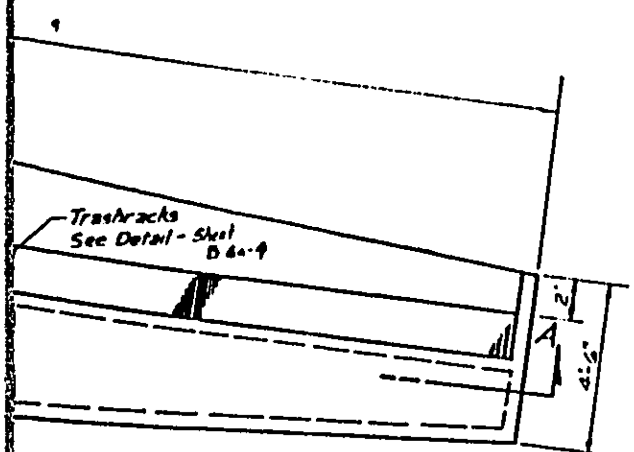


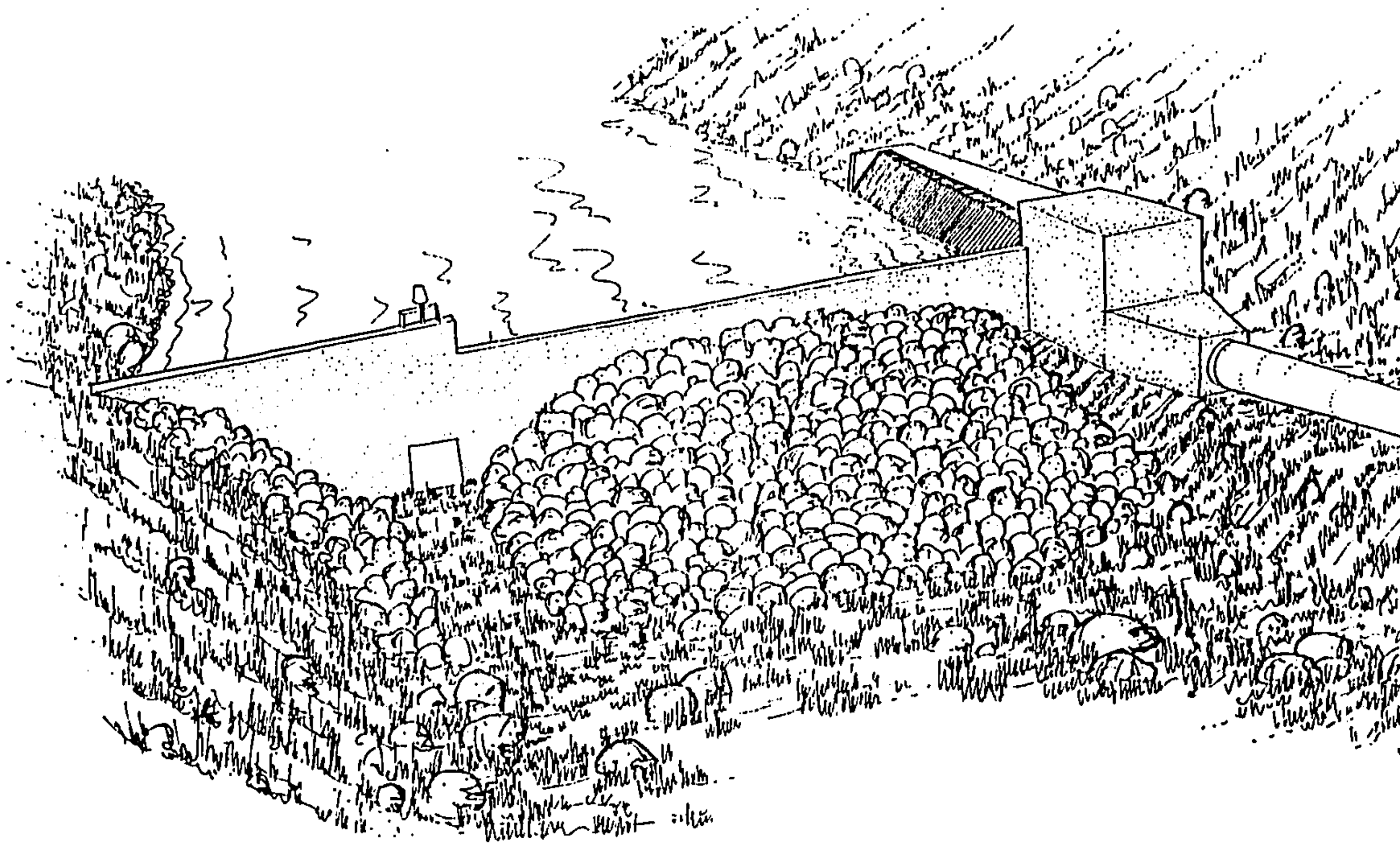
HANALEI HYDROELECTRIC PROJECT

TYPICAL FEEDER DIVERSION
INTAKE STRUCTURE

BINGHAM ENGINEERING

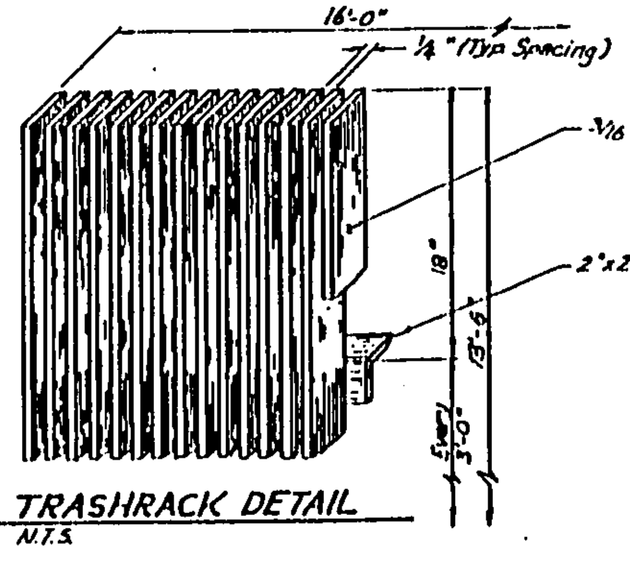
Rev	By	Date	Remarks

Date JAN 1987 | Project 609-014 | Sht B-6a-3



PERSPECTIVE SKETCH OF FEEDER DIVERSION

N.T.S.



TRASHRACK DETAIL

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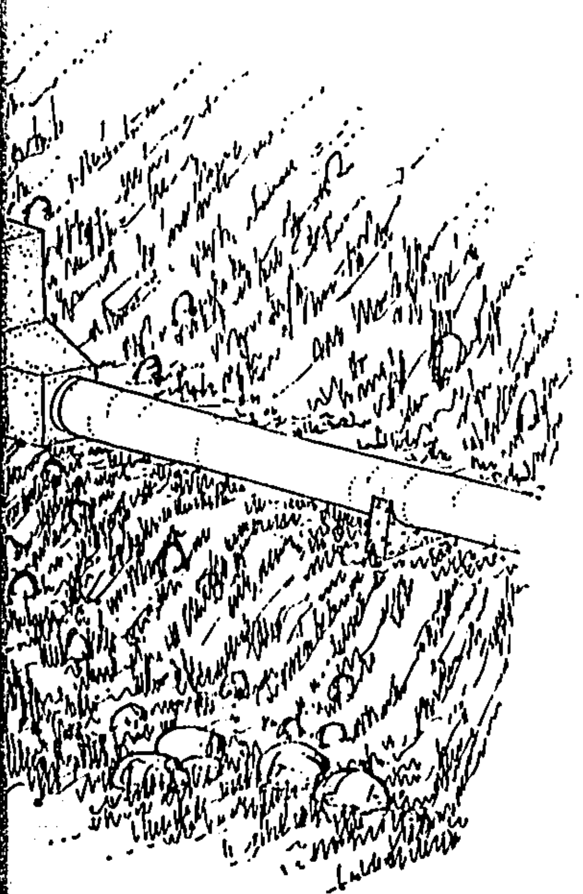

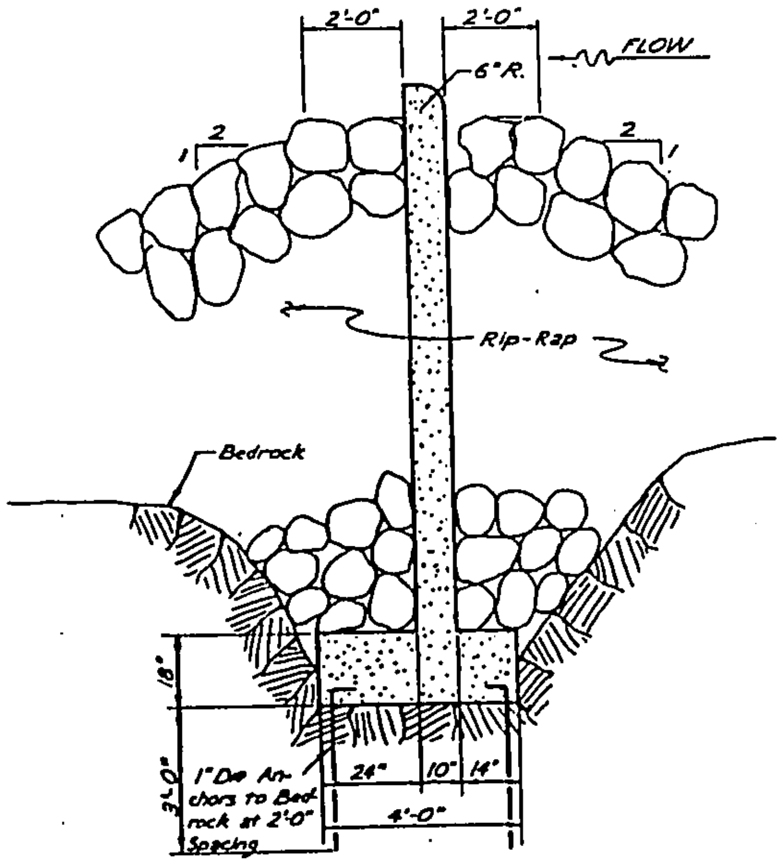

SECTION C-C

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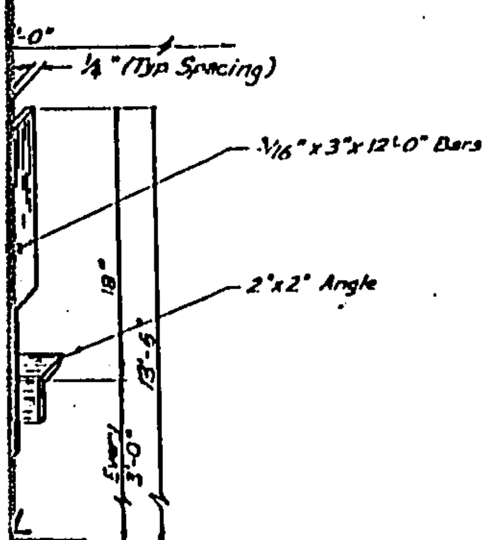
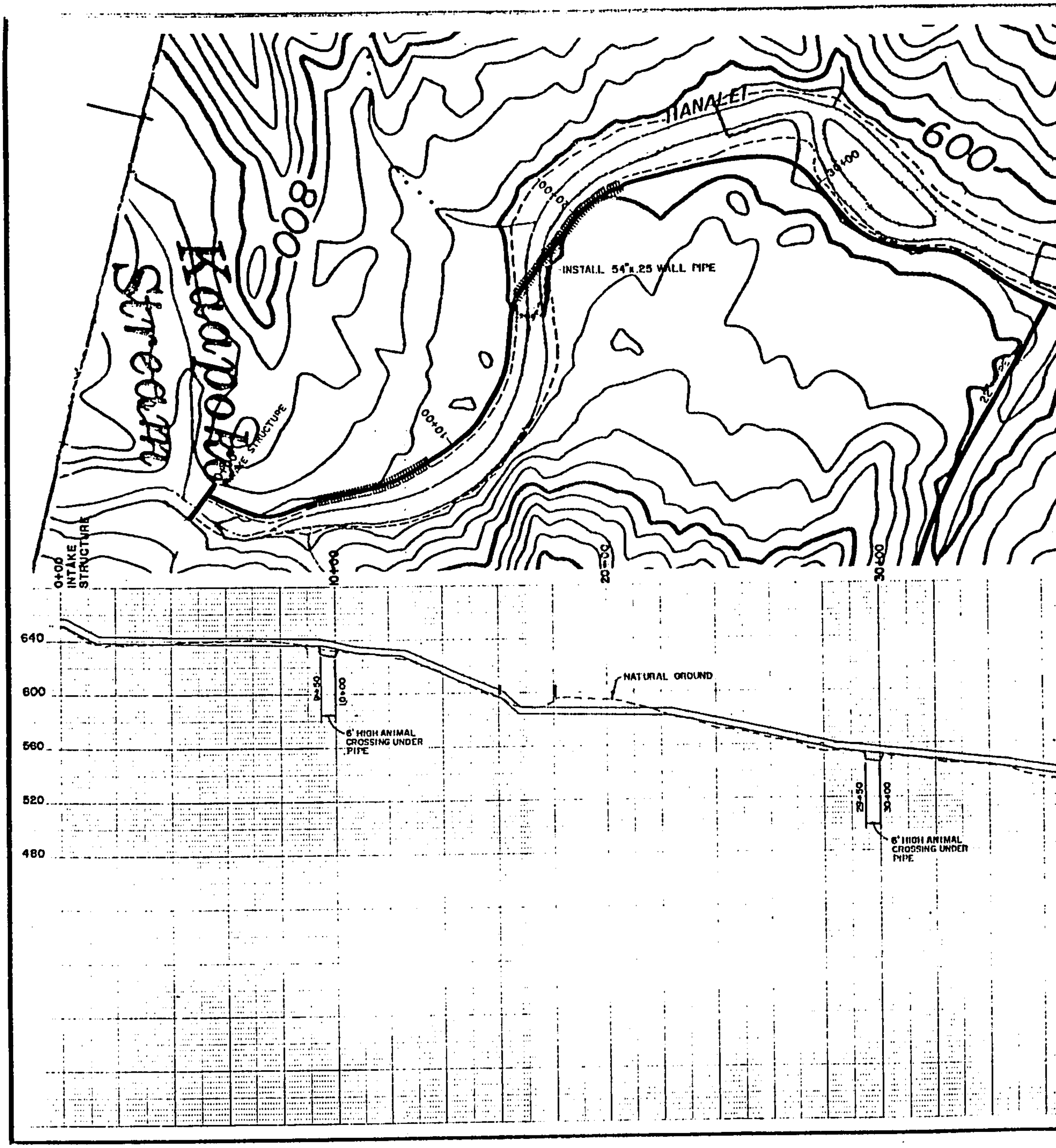


HANALEI HYDROELECTRIC PROJECT

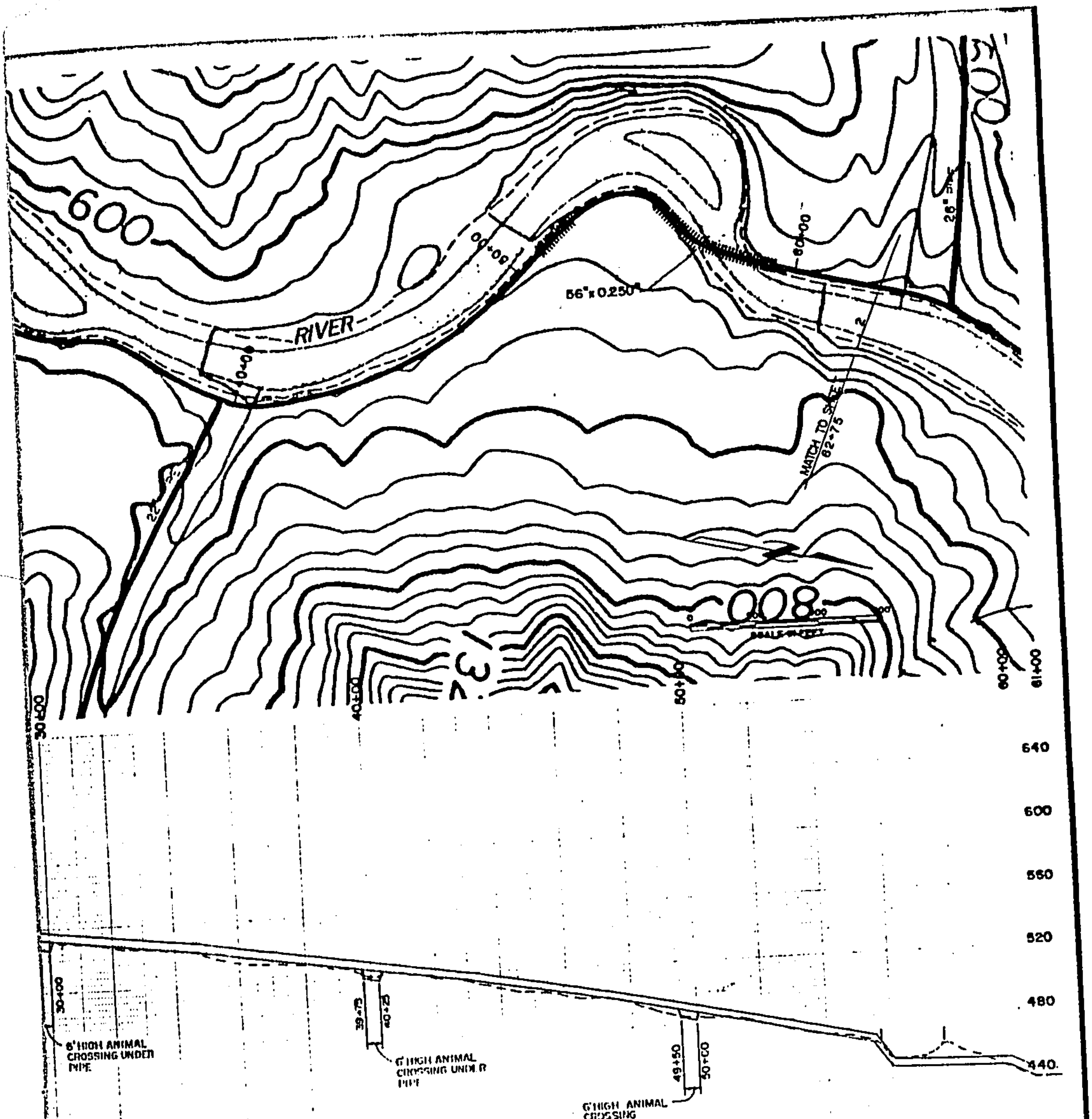
TYPICAL FEEDER DIVERSION INTAKE STRUCTURE DETAILS

BINGHAM ENGINEERING

Date JAN 1987 | Project # 609-014 | Sht B-6a-4



HANALEI
600
800
Kaapoko Stream
INTAKE STRUCTURE
INSTALL 54" x .25 WALL PIPE
0+00 INTAKE STRUCTURE
10+00
20+00
30+00
640
600
560
520
480
NATURAL GROUND
9+50
10+00
6' HIGH ANIMAL CROSSING UNDER PIPE
29+50
30+00
6' HIGH ANIMAL CROSSING UNDER PIPE



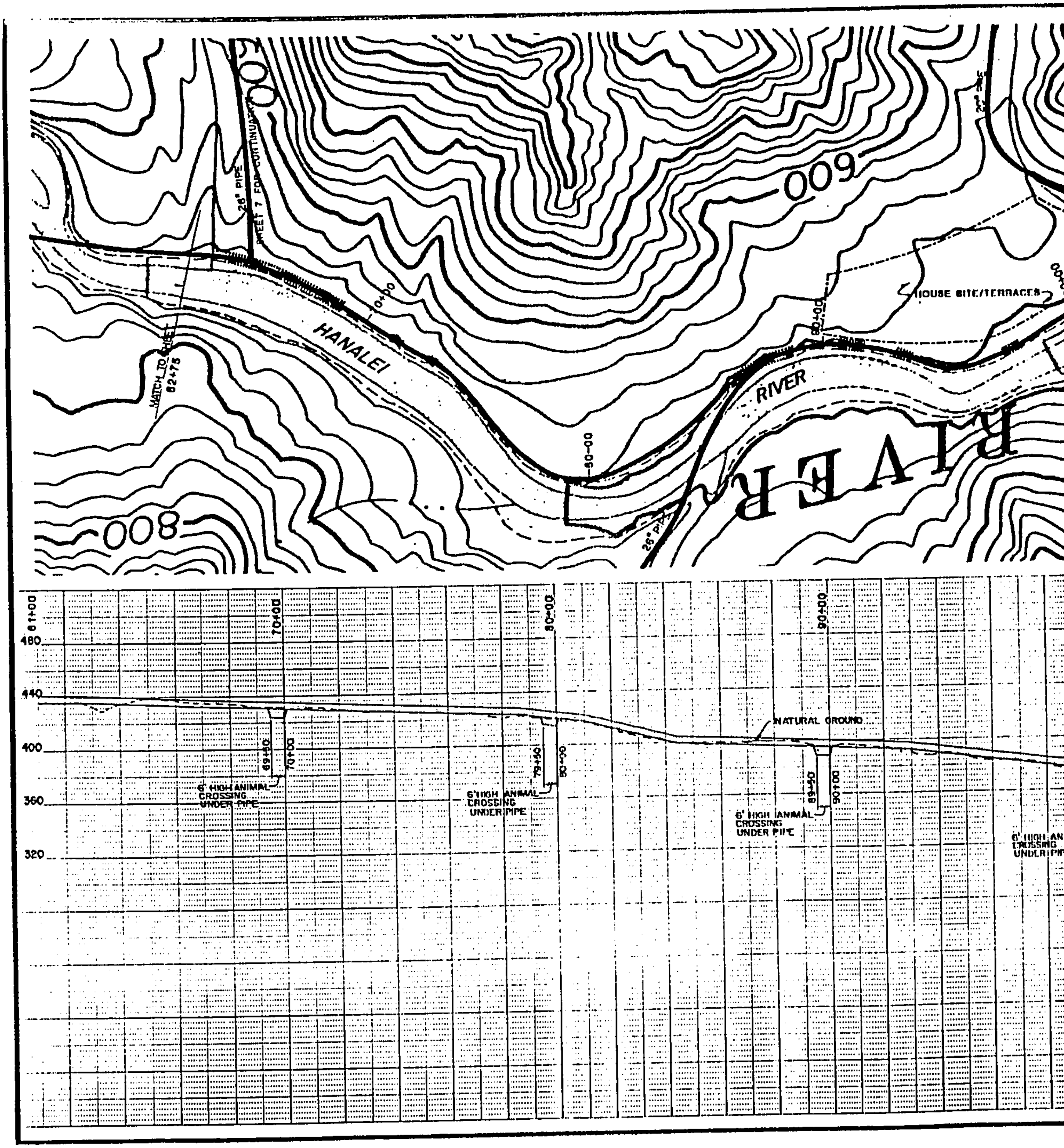
HANALEI HYDROELECTRIC PROJECT

PENSTOCK
PLAN & PROFILE

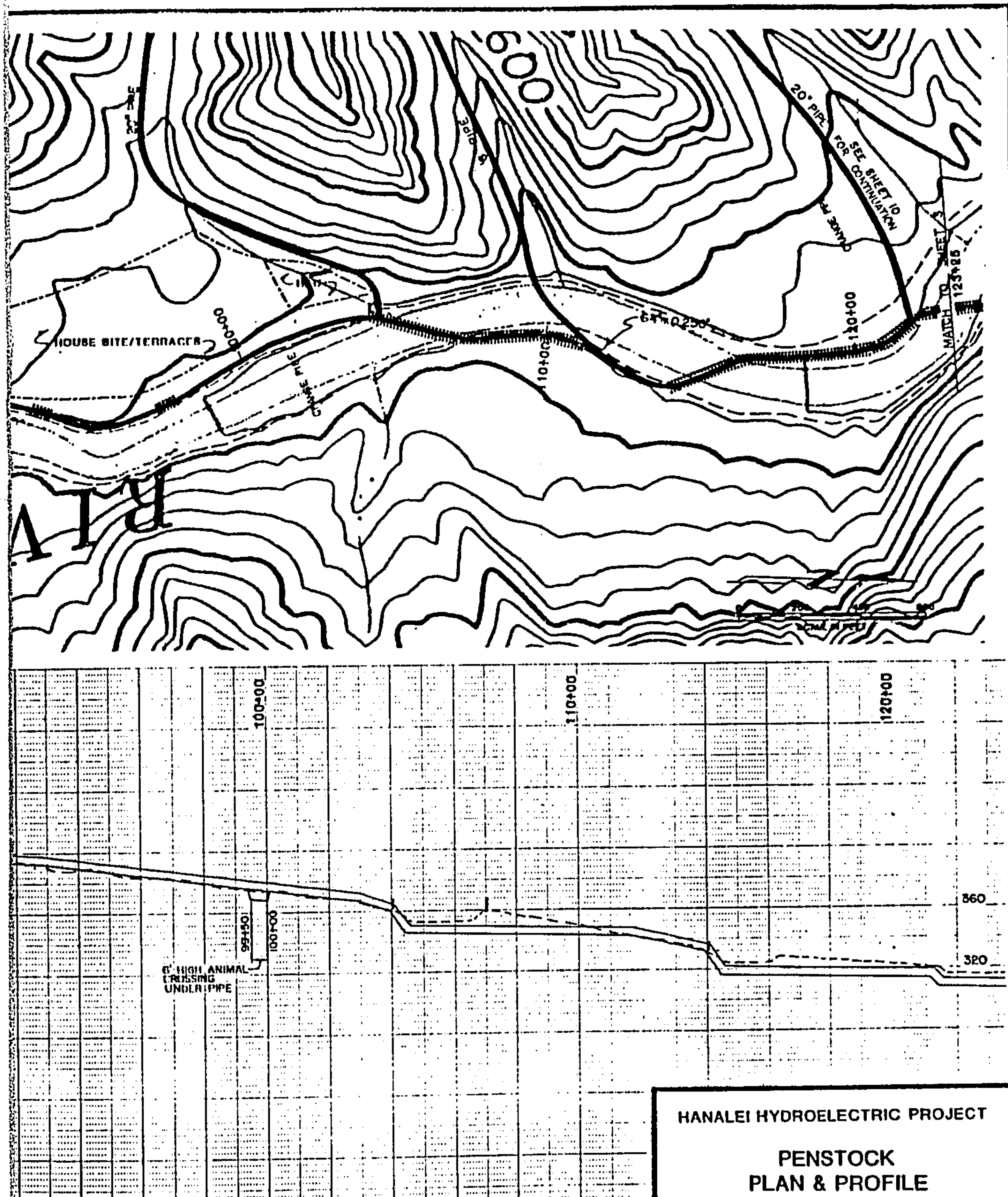
Bingham Engineering

Design J. Ovre
Drawn K. Ehrman J. Matheson

Date AUG 1986 | Project # 609-014 | B-6a-5



600
800
HANALEI
RIVER
RIVER
HOUSE SITE/TERRACES
28" PIPE
SHEET 7 FOR CONTINUATION
MATCH TO SHEET
62+75
70+00
80+00
90+00
61+00
480
440
400
360
320
NATURAL GROUND
69+50
70+00
6' HIGH ANIMAL CROSSING UNDER PIPE
79+50
80+00
6' HIGH ANIMAL CROSSING UNDER PIPE
89+50
90+00
6' HIGH ANIMAL CROSSING UNDER PIPE

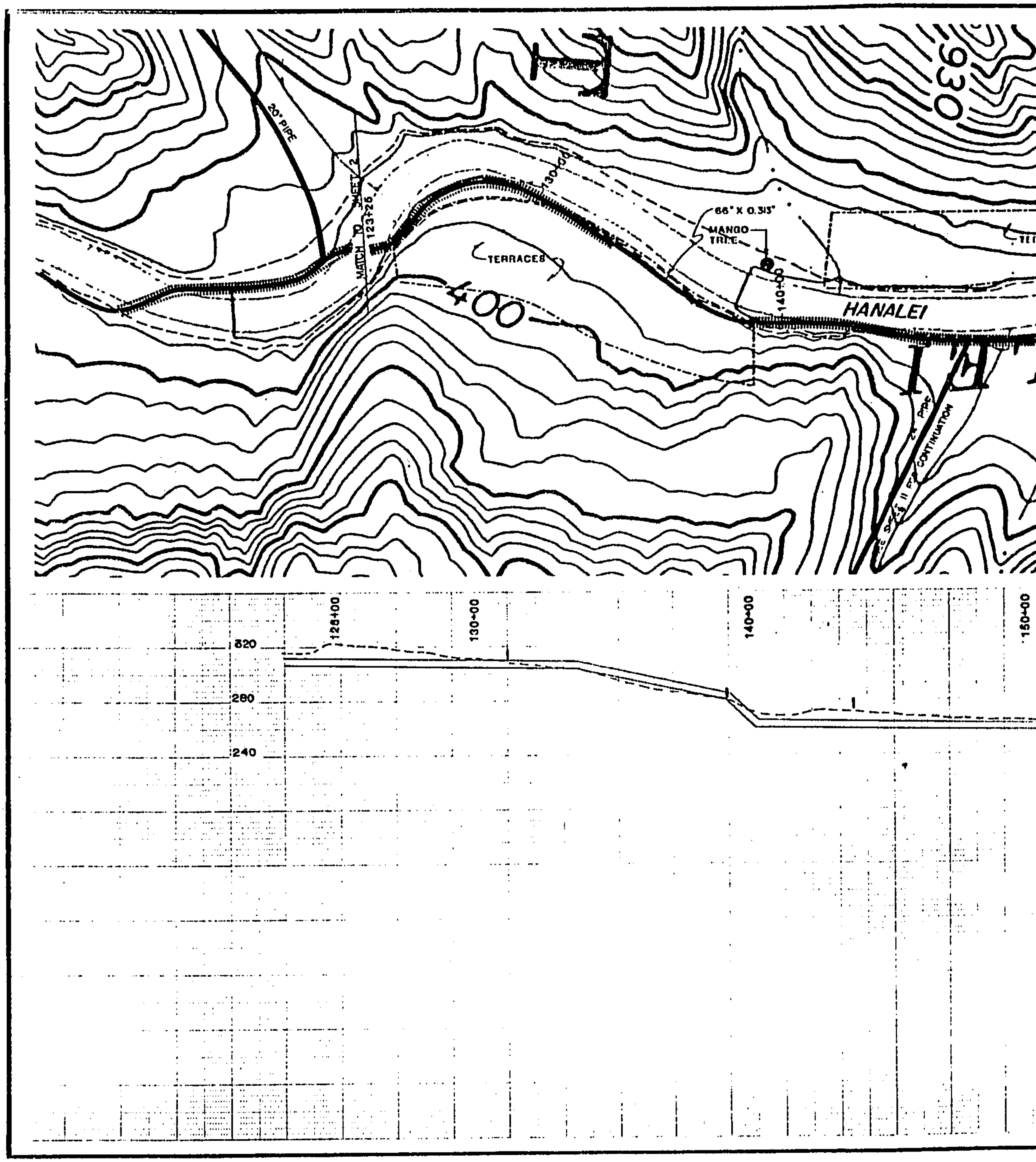


HANALEI HYDROELECTRIC PROJECT

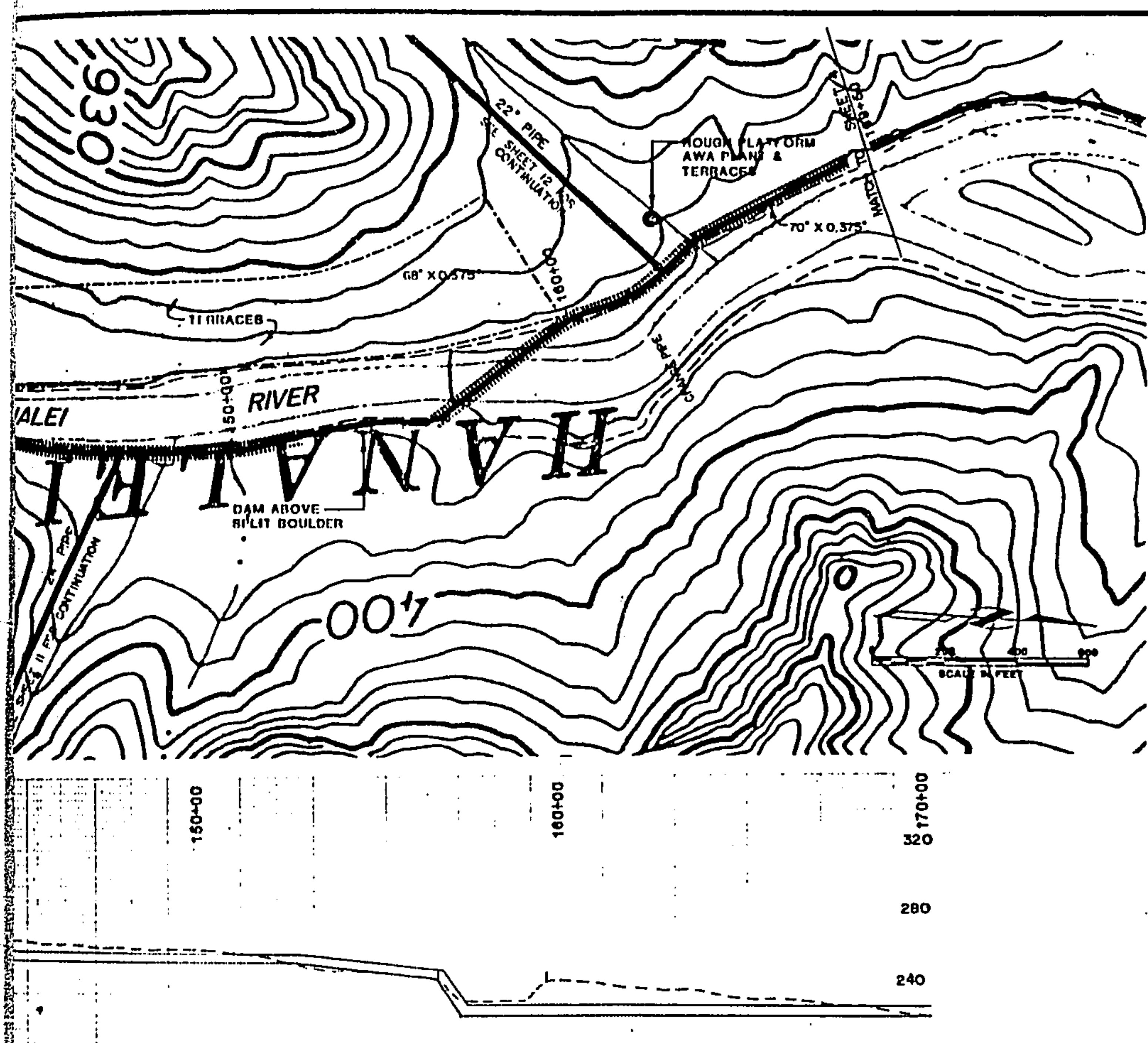
PENSTOCK
PLAN & PROFILE

Bingham Engineering

AUG 1986 | 609-014 | B-6a-6



20" PIPE
MATCH TO SHEET 2
123+25
130+00
66" X 0.315"
MANGO TREE
TERRACES
400
930
140+00
HANALEI
128+00
130+00
140+00
150+00
320
280
240



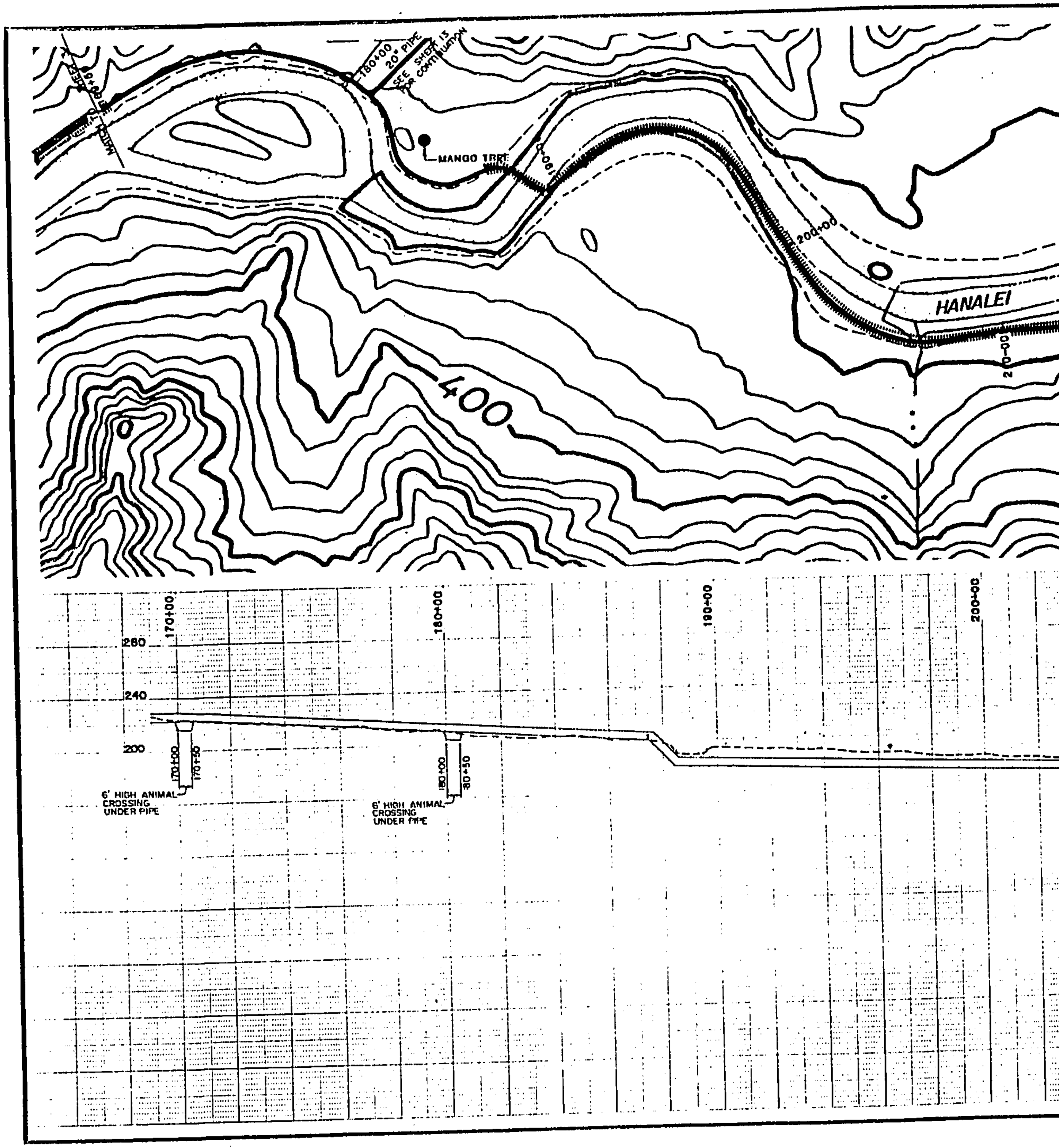
HANALEI HYDROELECTRIC PROJECT

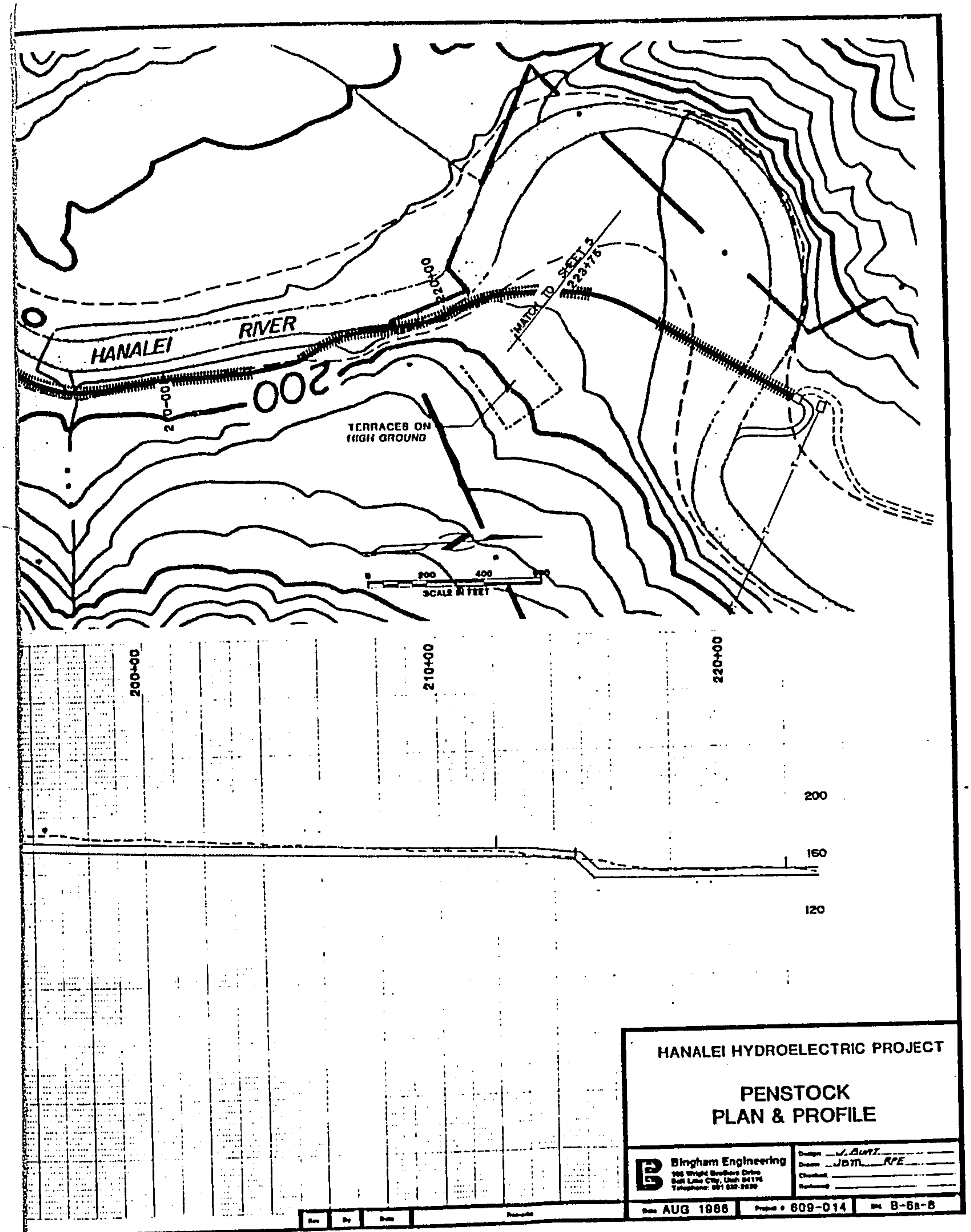
PENSTOCK
PLAN & PROFILE

Bingham Engineering

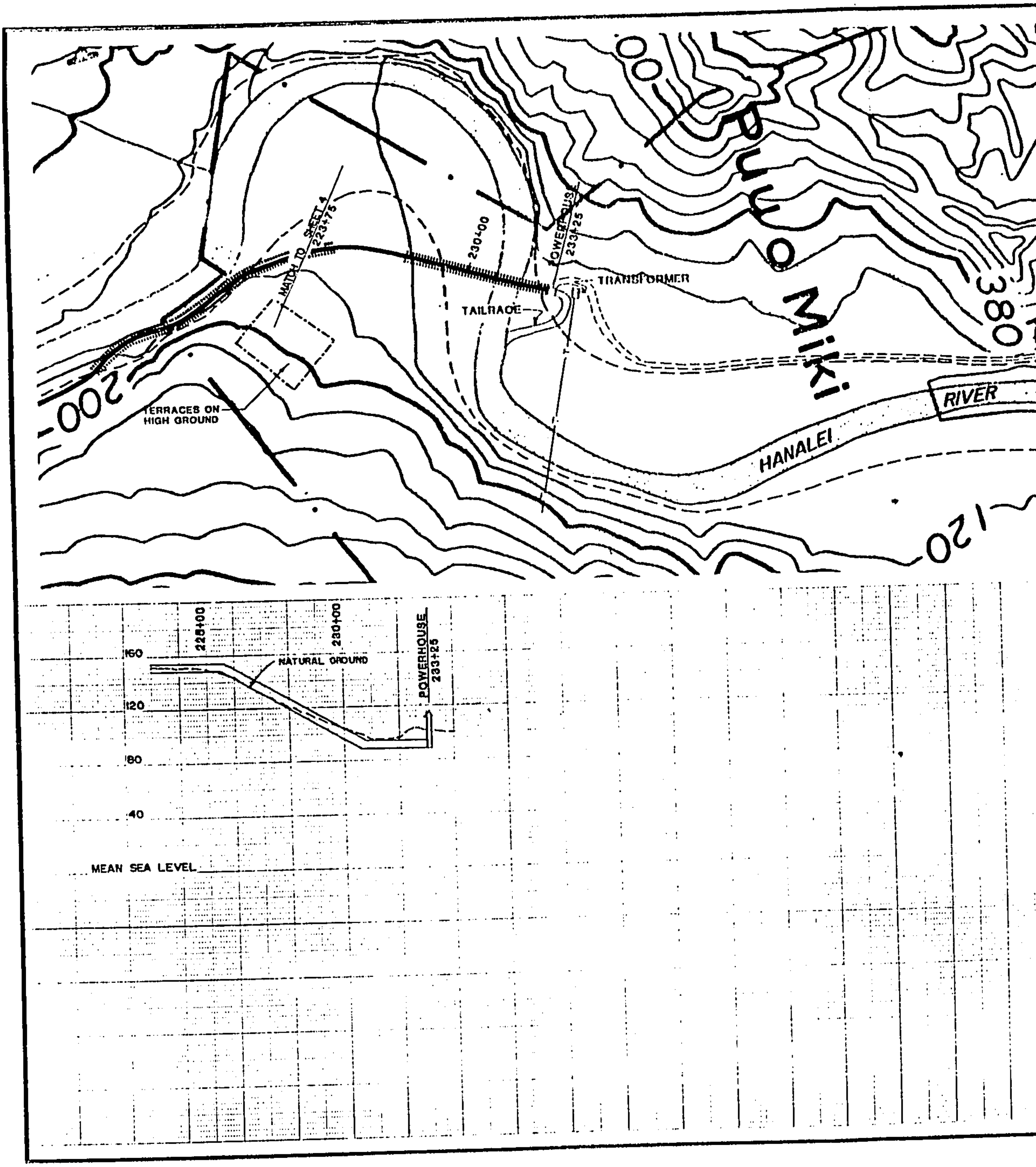
Design JJB
Drawn JDM KPE
Checked
Reviewed

Date AUG 1986
Project # 609-014
Sht B-6a-7

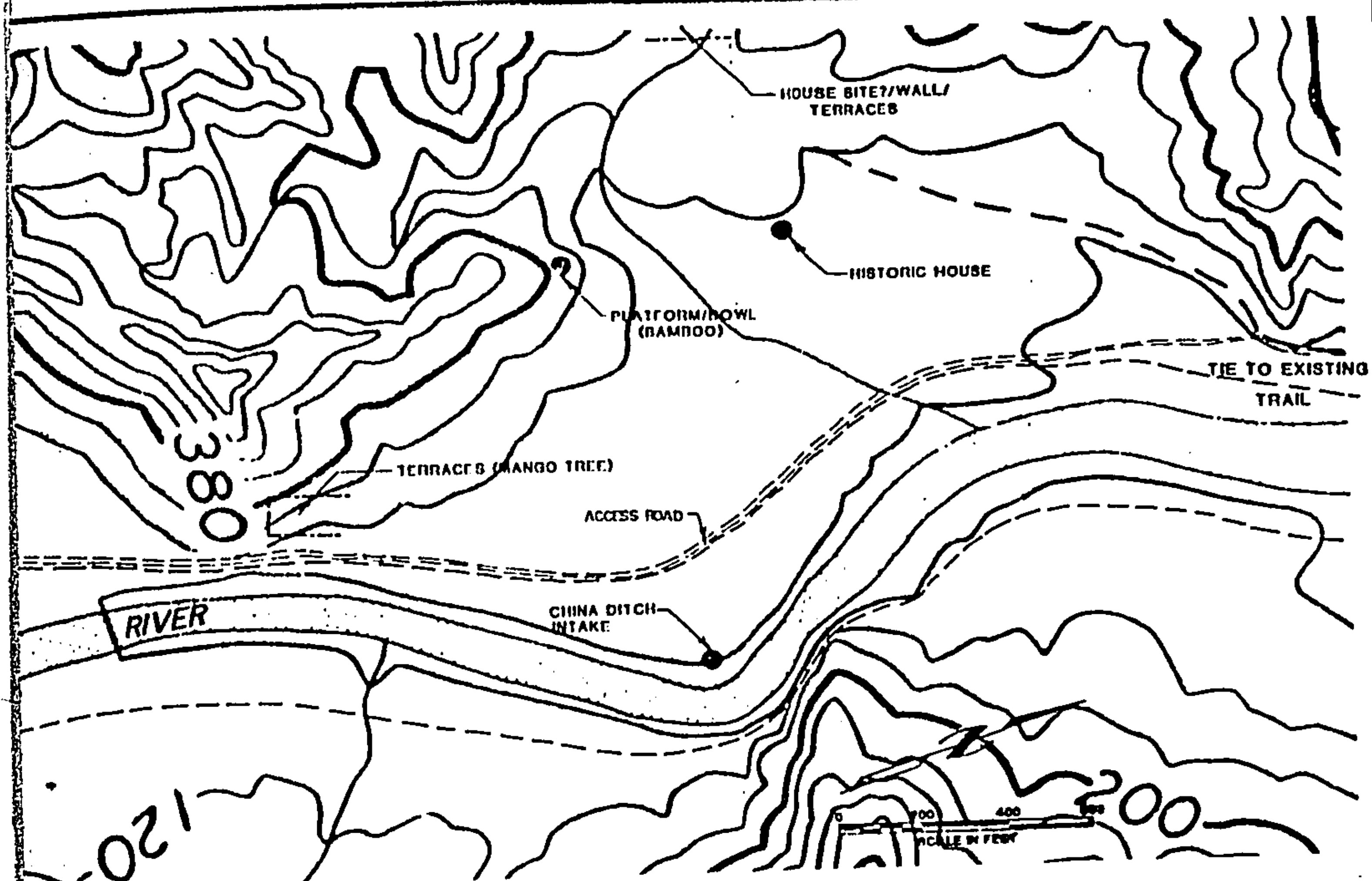

180+00
20" PIPE
SEE SHEET 13 FOR CONTINUATION
MANGO TREE
200+00
HANALEI
400
170+00
180+00
190+00
200+00
280
240
200
170+00
170+50
6' HIGH ANIMAL CROSSING UNDER PIPE
180+00
6' HIGH ANIMAL CROSSING UNDER PIPE



HANALEI
RIVER
200
220+00
MATCH TO SHEET 5
223+75
TERRACES ON
HIGH GROUND
SCALE IN FEET
200+00
210+00
220+00
200
160
120
HANALEI HYDROELECTRIC PROJECT
PENSTOCK
PLAN & PROFILE
Bingham Engineering
AUG 1986
609-014
B-6a-8



PUU O MIKI
MATCH TO SHEET 4
223+75
230+00
POWERHOUSE
233+25
TRANSFORMER
TAILRACE
TERRACES ON HIGH GROUND
HANALEI
RIVER
200
380
120
225+00
230+00
POWERHOUSE
233+25
NATURAL GROUND
160
120
80
40
MEAN SEA LEVEL



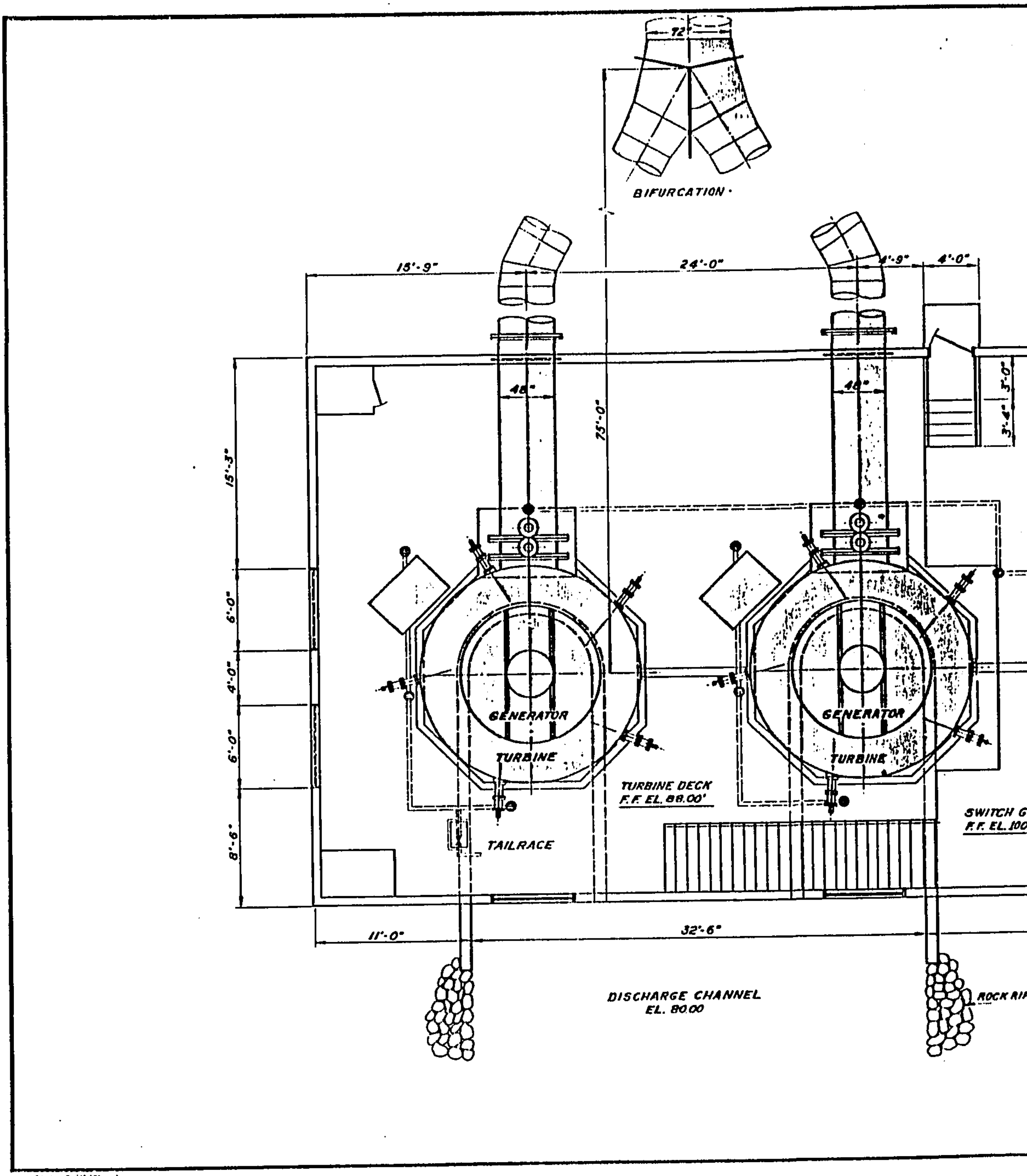
HANALEI HYDROELECTRIC PROJECT

PENSTOCK
PLAN & PROFILE

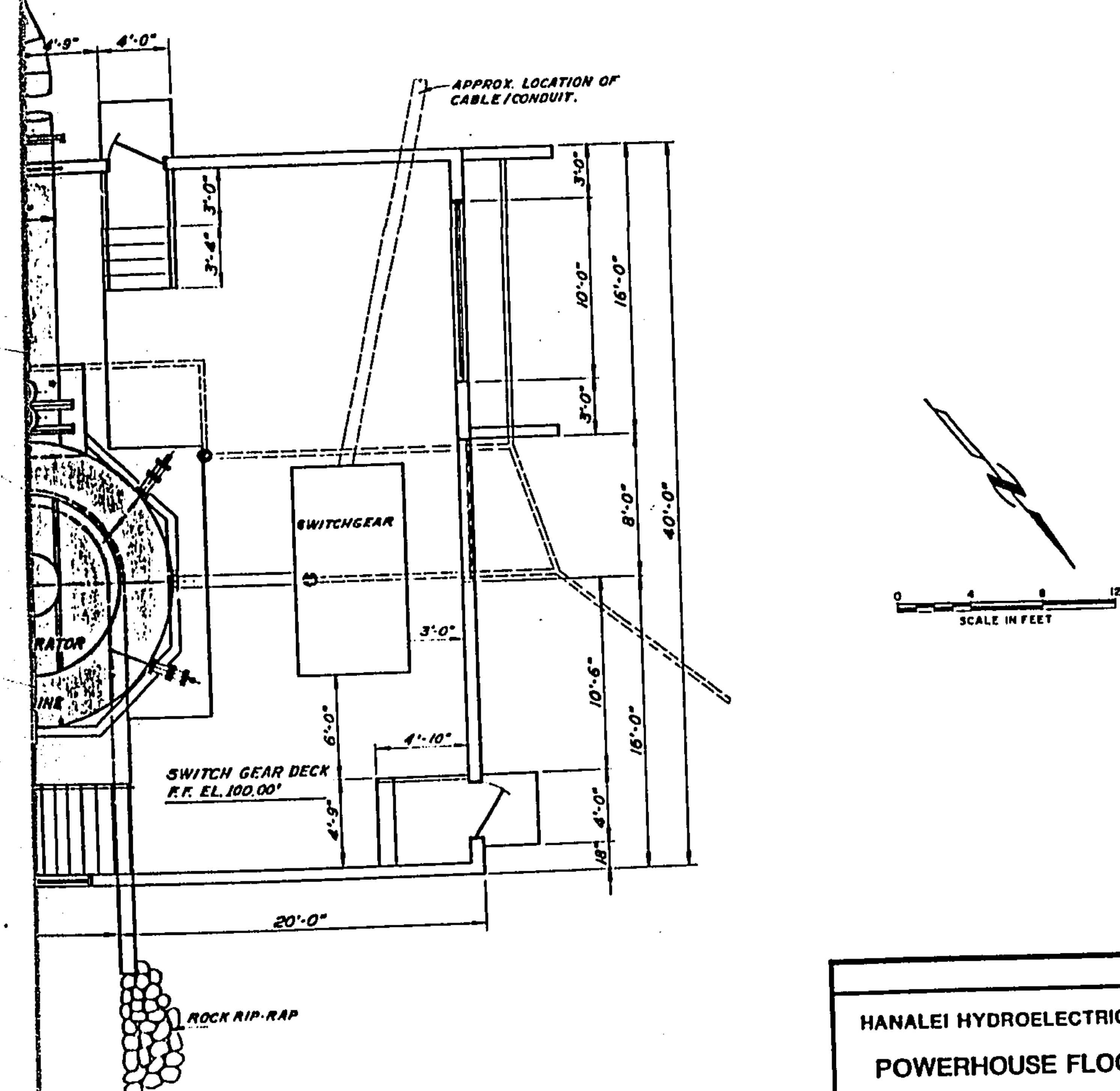
Bingham Engineering

Design J. BURT
Drawn JBM RPE

Date AUG 1986 | Project # 609-014 | Dwg B-6a-9



72"
BIFURCATION
18'-9"
24'-0"
4'-9"
4'-0"
48"
75'-0"
3'-0"
3'-4"
15'-3"
6'-0"
4'-0"
6'-0"
8'-6"
GENERATOR
TURBINE
GENERATOR
TURBINE
TURBINE DECK
F.F. EL. 88.00'
TAILRACE
11'-0"
32'-6"
DISCHARGE CHANNEL
EL. 80.00



HANALEI HYDROELECTRIC PROJECT

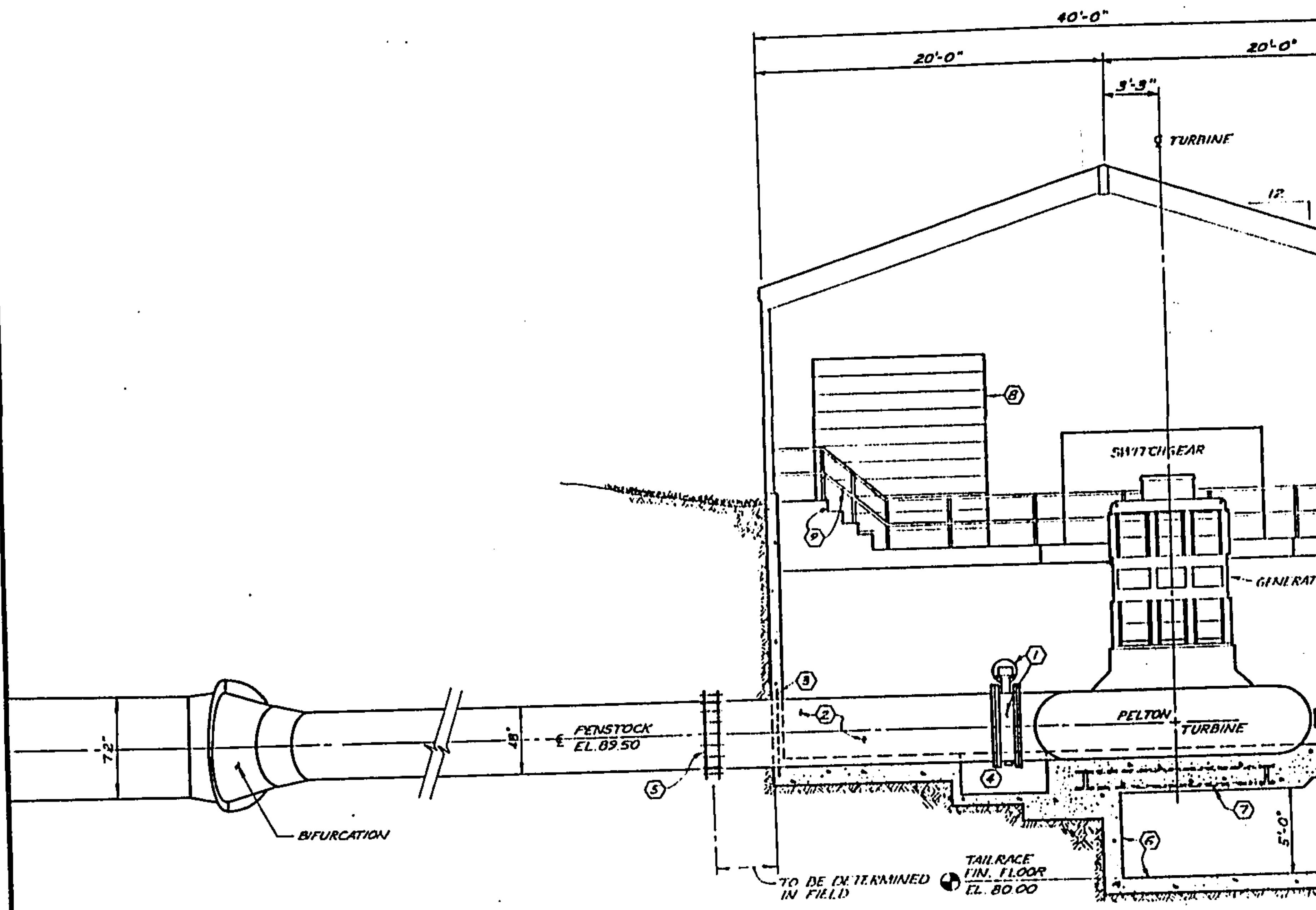
POWERHOUSE FLOOR PLAN

BINGHAM ENGINEERING

Design: B.C. WATTA
Drawn: EDDY FRANCO
Checked:
Approved:

Rev	By	Date	Remarks

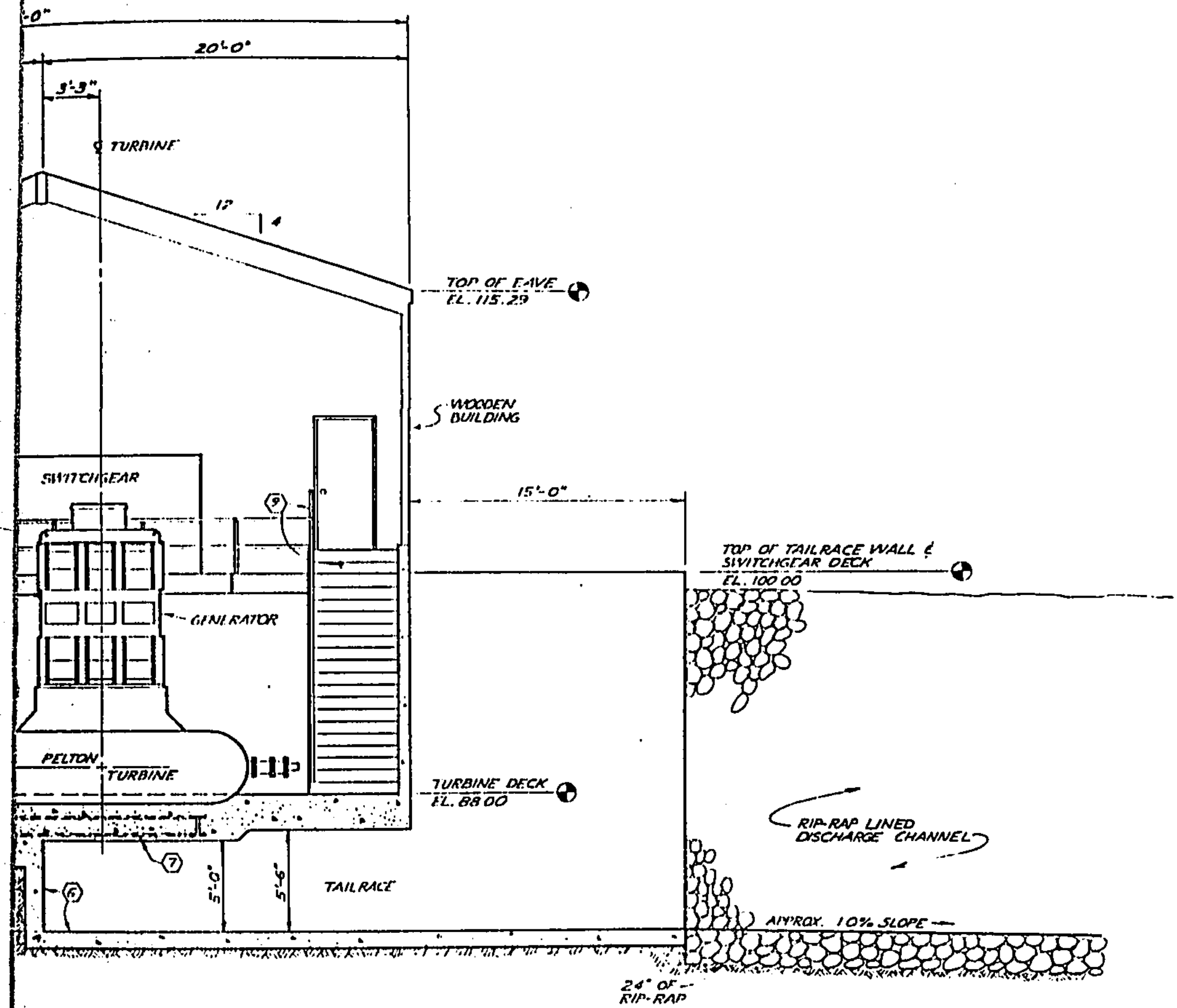
Date JAN.1987 | Project # 609-014 | Dwg B-6a-10



POWERHOUSE BUILDING SE

SCALE - 1"=4'-0"

1. 48" BUTTERFLY VALVE & ACTUATOR.
2. 48" O.D. STEEL PENSTOCK TO BE INSTALLED BY FOUNDATION CONTRACTOR. PREPARE PIPE EXPOSED WITHIN BUILDING FOR FINISH PAINTING BY OTHERS EXTERIOR PIPE WALLS TO HAVE TWO COATS OF RED OXIDE PRIMER PRIOR TO INSTALLATION.
3. 3/8" STEEL SEEPAGE RING, 48" I.D., 56" O.D., FILLET WELD TO PENSTOCK PRIOR TO PAINTING. PROVIDE #4 BARS HORIZONTAL, VERTICAL, & DIAGONALLY AROUND PENSTOCK W/3" MIN. CLEARANCE.
4. RECESSED VALVE ACCESS PIT COVERED W/1/4" GALV. DECK PLATE TO PREVENT SAGGING.
5. 48" DIA. DRESSER COUPLING
6. ROLLED STEEL TAILRACE LINER.
7. PRE-FABRICATED STEEL WIDE FLANGE BASE FRAME.
8. 10' WIDE x 12' HIGH STEEL OVERHEAD DOOR IN STEEL JAMB WITH WEATHER SEAL & INSIDE LOCK MECHANISM.
9. CONC. STAIRWAY W/ HANDRAILS. SEE FLOOR PLAN.



OUSE BUILDING SECTION

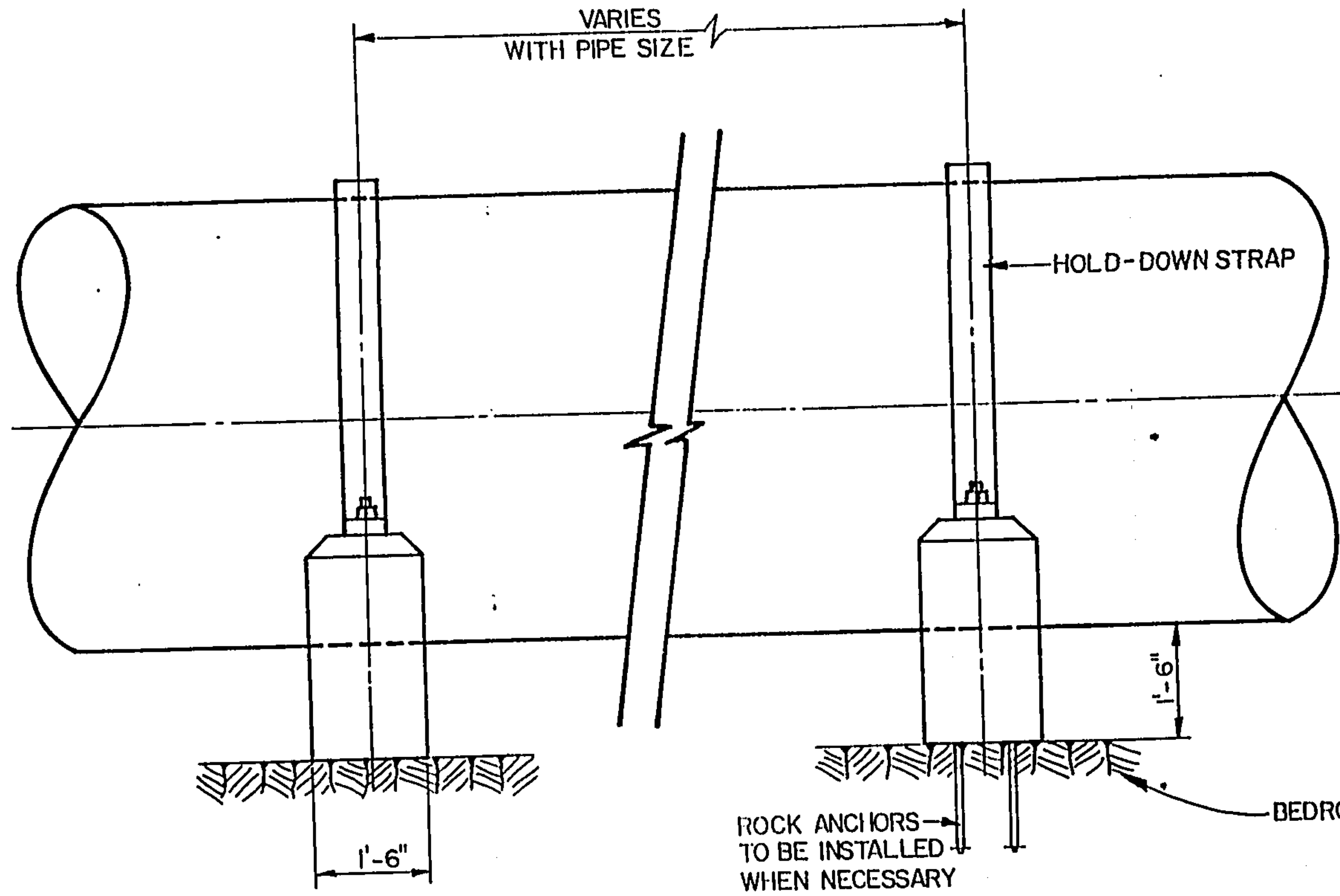
HANALEI HYDROELECTRIC PROJECT

POWERHOUSE BUILDING SECTION

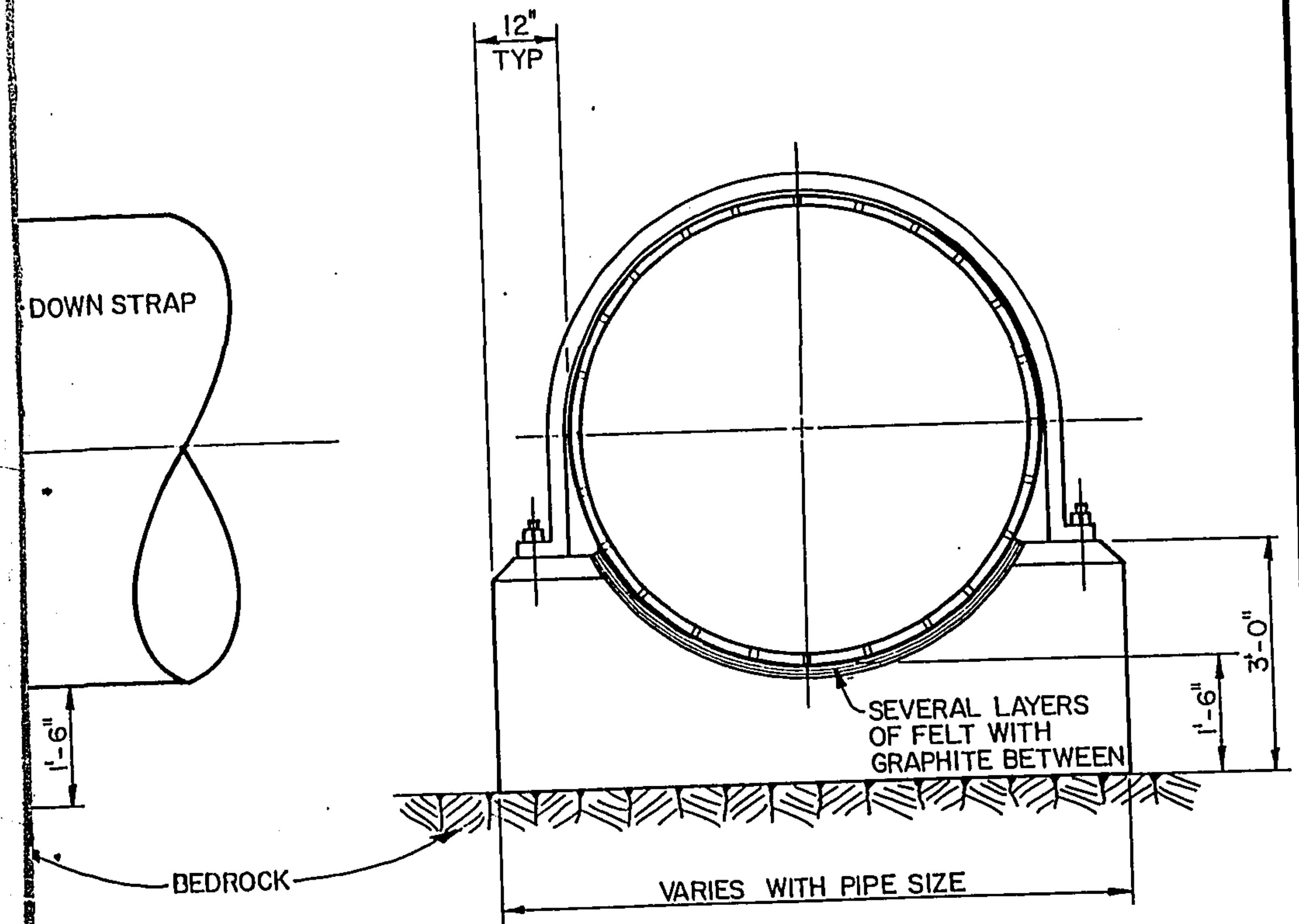
BINGHAM ENGINEERING

Drawn R.P.Ehrman

Date JAN.1987 | Project # 609-014 | Dwg B-6a-11



VARIES
WITH PIPE SIZE
HOLD-DOWN STRAP
1'-6"
1'-6"
ROCK ANCHORS
TO BE INSTALLED
WHEN NECESSARY
BEDR
SCALE 1'= 2'-0"



LE 1"= 2'-0"

HANALEI HYDROELECTRIC
PROJECT

TYPICAL
PENSTOCK SUPPORT DETAIL

BINGHAM ENGINEERING

JAN 1987 | 609-014 | B-6a-12

B-6b HYDROLOGIC INVESTIGATIONS

B-6b HYDROLOGIC INVESTIGATIONS

RAINFALL

The average annual rainfall on Kauai varies from approximately 50 inches near the coastline to over 450 inches on Mount Waialeale.

FLOW GAGING STATIONS

The total drainage area in the Hanalei Basin at gage 16103000 is 19.1 square miles. Figure B-1 illustrates the location and annual mean flow of the U.S.G.S. gaging stations in the basin. Table B-6b-1 lists the stream gaging stations operated by the U.S. Geological Survey in the Hanalei Basin.

IRRIGATION DIVERSION

The Hanalei River Basin is shown on Figure B-1. A description of the diversions occurring in the Hanalei Basin follows:

a. The Hanalei Tunnel conveys waters from the Hanalei River Basin into the North Fork Wailua River Basin from which the water is conveyed downstream for irrigation in the vicinity of Lihue and Kapaa.

b. Streamflows from the Hanalei River are diverted into the China Ditch approximately 1 river mile downstream from the proposed powerhouse. This ditch is used to provide flows for agricultural uses in the Hanalei Valley.

c. Streamflows are diverted from the Hanalei River into the Kuna Ditch approximately 1.5 river miles downstream from the proposed powerhouse. This ditch is used to provide flows for agricultural uses in the Hanalei Valley.

d. In formulating alternatives, it was assumed that the historical diversions and the external outflows will continue.

TABLE B-6b-1

USGS STREAM GAGING STATIONS

USGS STATION NUMBER	USGS STATION NAME	DRAINAGE AREA (SQ.MI.)	ELEVATION (FEET)	PERIOD OF RECORD
16100000	Hanalei Tunnel Outlet near Lihue	---	1,210	1932-current
16101000	Hanalei River at Alt 625	7.17	625	1914-1955
16102000	China Ditch near Hanalei	---	70	1912-1919
16103000	Hanalei River near Hanalei	19.1	35.8	1912-1919 1963-current

HYDROLOGIC ANALYSIS

Based on the early 1914-1919 period before the Hanalei tunnel export, the total yield of the Hanalei Basin at USGS Station 16103000 was 253,400 ac-ft (350 cfs). By comparison, the yield at USGS Station 16101000 was 89,100 ac-ft (123 cfs) or 35% of the total basin yield. In more recent times the total Hanalei Basin yield at USGS Station 16103000 for the 1964-84 period was 196,200 ac-ft (270.7 cfs) assuming the China Ditch station 16102000 has continued to divert approximately 20,300 ac-ft (27.4 cfs) during this period. This also includes flows which were exported from the basin through the Hanalei tunnel. In order to determine the yield at USGS Station 16101000, during this period, it was correlated with 16103000. This yielded 69,500 ac-ft (96.1 cfs) before subtracting out 18,800 ac-ft (26 cfs) for the Hanalei tunnel export from gage 16100000, which resulted in a net yield of 50,700 ac-ft (70.1 cfs) for the 1964-84 time period. This also shows the yield at USGS Station 16101000 to be 35% of the basin for the 1964-1984 time period. The yield of the upper basin to gage 16101000 is slightly less than the yield of the remaining basin on a per square mile basis. Table B-6b-2 summarizes the mean monthly flows for the China Ditch at USGS Station 16102000 for the period 1915-1919. Table B-6b-3 summarizes the mean monthly flows at USGS Station 16103000 for the period 1964-1984. The combination of these stations was made to determine the total mean monthly flow distribution of the Hanalei River which resulted in mean annual flow of 244.7 cfs.

The Hanalei Basin at USGS station 16103000 is comprised of 22 sub-basins. For the purpose of this study, each basin was identified using the letters A through V. The identification and location of each sub-basin are shown on Figure B-2. To estimate the annual yield of the 22 sub-basins in the watershed, an area-altitude precipitation method was used. Table B-6b-4 summarizes the area of each of the 22 sub-basins with their respective elevation. For basins A and B the yield at station 16101000 was used in the analysis. For basins C through V, the reach gain from gage 16101000 to gages 16102000 and 16103000 was used. The distribution of the annual flows on a daily and monthly basis was calculated for each sub-basin by proportioning the flows as a fraction of the total basin yield from the sub-basin yields. The resulting mean monthly flows for the 22 sub-basins for the 1964-84 period is shown on Table B-6b-5.

Table B-6b-6 simulates the flow which will remain in the Hanalei River under project operating conditions and summmarizes the mean monthly flows not used by the Project. These flows are a result of a combination of several factors including flows not diverted, flows exceeding diversion capacity and a continuous minimum by-pass flow of 10 cfs.

Table B-6b-7 shows the mean annual flows of the 22 Sub-basins under project conditions which are both used and not used by the Project.

ROLE IN PROJECT FORMULATION

In order to determine which of the 22 sub-basins to divert for power production, a comparison of the mean annual flows of each sub-basin was made. However, sub-basins R-V were not considered for diversion because they are located too far downstream from the main diversion weir for practical use. As a general rule, sub-basins with a mean annual flow of 6 cfs or greater were considered to be adequate for project utilization.

Based on this analysis, the sub-basins selected for project use were A,B,F,G,I,K,L,M,O,P,Q. Table B-6b-8 summarzies the mean annual flow for each of these sub-basins along with the proposed maximum flow diversion for power generation.

USGS 1602000 (CFS) CHINA DITCH

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1915	2.	7.	4.	5.	19.	29.	39.	26.	38.	40.	37.	32.	23.
1916	34.	29.	20.	20.	15.	28.	36.	32.	34.	39.	38.	33.	30.
1917	31.	34.	27.	18.	24.	28.	28.	29.	31.	31.	32.	32.	29.
1918	30.	25.	20.	23.	28.	33.	34.	31.	27.	30.	26.	23.	28.
1919	24.	24.	15.	15.	23.	27.	29.	35.	32.	40.	38.	32.	28.
MEAN	24.	24.	17.	16.	22.	29.	33.	31.	32.	36.	34.	30.	27.
PCT	7.35%	7.41%	5.22%	4.92%	6.56%	8.60%	10.08%	9.29%	9.84%	10.93%	10.38%	9.23%	100.00%
SD	13.	10.	9.	7.	5.	2.	5.	3.	4.	5.	5.	4.	3.
CV	0.53	0.42	0.50	0.43	0.24	0.08	0.14	0.11	0.12	0.14	0.15	0.14	0.09

TABLE 8-6b-2

BINGHAM ENGINEERING HYDROLOGY DIVISION

USGS STATION 16103000

SUMMARY TABLE

PERIOD 1964·1984

AVERAGE MONTHLY FLOWS (CFS)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1964	178.	73.	66.	273.	221.	597.	266.	284.	98.	253.	143.	147.	2597.
1965	336.	579.	559.	287.	280.	204.	512.	431.	228.	320.	146.	112.	3994.
1966	363.	744.	343.	171.	295.	104.	76.	75.	67.	210.	206.	72.	2727.
1967	267.	268.	330.	262.	320.	372.	311.	626.	90.	125.	234.	105.	3310.
1968	116.	403.	596.	198.	123.	348.	249.	142.	106.	144.	97.	91.	2612.
1969	223.	345.	354.	279.	588.	313.	206.	332.	99.	251.	112.	176.	3279.
1970	157.	168.	225.	253.	68.	56.	310.	145.	79.	146.	105.	118.	1830.
1971	94.	280.	348.	217.	159.	331.	671.	142.	82.	95.	61.	83.	2563.
1972	98.	137.	345.	214.	368.	144.	378.	123.	101.	216.	88.	99.	2312.
1973	160.	188.	77.	99.	224.	278.	143.	232.	100.	77.	42.	51.	1672.
1974	104.	437.	254.	210.	192.	369.	781.	444.	219.	239.	140.	207.	3595.
1975	105.	488.	189.	498.	247.	310.	185.	104.	57.	67.	53.	36.	2339.
1976	87.	221.	96.	247.	278.	437.	425.	145.	93.	129.	99.	67.	2324.
1977	133.	91.	63.	62.	193.	286.	203.	246.	139.	125.	105.	59.	1706.
1978	101.	138.	171.	65.	43.	90.	227.	227.	568.	188.	277.	147.	2241.
1979	200.	333.	187.	286.	592.	112.	94.	153.	168.	84.	113.	52.	2375.
1980	73.	158.	131.	157.	58.	471.	528.	328.	303.	322.	123.	151.	2804.
1981	183.	169.	115.	76.	186.	140.	369.	149.	82.	195.	223.	79.	1966.
1982	207.	553.	359.	294.	427.	1096.	459.	238.	179.	394.	413.	280.	4898.
1983	466.	511.	226.	162.	84.	70.	150.	199.	90.	171.	226.	120.	2473.
1984	187.	93.	60.	94.	90.	61.	199.	74.	84.	63.	57.	54.	1114.

MONTHLY AVERAGE IN (CFS)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
	183.	304.	243.	210.	240.	295.	321.	230.	144.	182.	146.	110.	2606.

TABLE B-6b-3

HANALEI RIVER
DRAINAGE BASIN AREAS BY ELEVATION
(AREAS IN SQUARE MILES)

ELEVATION (FEET ABOVE MSL)

BASIN	0-400	400-800	800-1200	1200-1600	1600-2000	2000-2400	2400-2800	2800-3200	3200-3600	3600-4000	4000-4400	4400 +	TOTAL
A		0.11	0.90	0.84	1.26	0.28	0.06	0.03	0.07	0.01			3.58
B				0.22	0.50	0.66	0.51	0.34	0.18	0.23	0.27	0.29	3.20
C		0.02	0.07	0.07	0.01								0.17
D		0.08	0.03	0.04	0.02	0.01							0.18
E		0.09	0.06	0.09	0.06	0.04	0.02	0.01					0.37
F		0.23	0.17	0.27	0.35	0.05							1.07
G	0.01	0.18	0.22	0.12	0.05	0.06	0.09	0.14	0.11	0.07	0.03		1.08
H		0.03	0.02	0.05									0.10
I	0.01	0.21	0.40	0.40	0.54	0.68							1.54
J	0.01	0.06	0.05	0.05									0.17
K	0.01	0.05	0.11	0.09	0.06	0.03	0.02	0.04	0.03	0.01	0.02		0.47
L	0.01	0.11	0.05	0.04	0.03	0.02	0.02	0.03	0.02	0.02	0.03		0.38
M	0.02	0.08	0.12	0.39	0.06	0.05	0.04	0.06	0.02	0.02	0.02		0.58
N	0.03	0.04	0.06	0.02	0.01								0.16
O	0.08	0.13	0.39	0.50	0.04								1.14
P	0.03	0.11	0.13	0.15	0.13	0.08	0.05	0.07	0.03	0.01	0.02		0.81
Q	0.13	0.14	0.19	0.15	0.11	0.04	0.01						0.77
R	0.21	0.16	0.30	0.01									0.68
S	0.03	0.05	0.07	0.06	0.06	0.05	0.01						0.33
T	0.03	0.06	0.05	0.04	0.04	0.02							0.24
U	0.36	0.20	0.35										0.91
V	0.49	0.35	0.16	0.03	0.01								1.34
TOTALS	1.46	2.49	3.90	3.35	3.34	1.47	0.83	0.72	0.45	0.40	0.39	0.29	19.10

TABLE B-6b-4

DATE: 09/01/86

HANALEI RIVER HYDROELECTRIC PROJECT
DRAINAGE BASIN ANALYSIS

COMBINED FLOWS OF
USGS STATION # 16102000 -(CHINA DITCH)
YEARS (1915-1919)
USGS STATION # 16103000
YEARS (1961-1984)
TOTAL MEAN ANNUAL FLOW - 244.7 CFS

LATITUDE 22 11 31 LONGITUDE 159 27 57

TOTAL MEAN MONTHLY FLOW SUMMARY
PRESENT CONDITION
(INCLUDES CHINA DITCH)

DRAINAGE AREA 19.1 SQ. MI.

DATUM 35.3

BASIN	AREA	RIV. MI	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	MEAN	ACCUM. FLOW	% TOTAL FLOW	ACCUM. % FLOW
			MEAN MONTHLY FLOW (CFS)															
* ** A,B	6.8	11.1	58.7	93.9	74.8	63.8	75.8	93.0	102.0	75.8	50.3	62.1	52.6	39.7	70.1	70.1	28.7	28.7
C	0.2	11.0	2.5	3.4	2.4	2.4	2.4	3.5	3.6	2.5	1.4	2.7	1.4	1.5	2.5	72.6	1.0	29.7
D	0.2	10.7	2.6	3.5	2.5	2.5	2.5	3.6	3.7	2.6	1.5	2.8	1.5	1.6	2.6	75.2	1.1	30.7
E	0.4	10.5	4.5	7.5	6.4	5.4	6.6	7.7	7.8	5.7	3.7	4.8	3.7	3.9	5.6	80.8	2.3	33.0
* F	1.1	10.3	13.8	21.6	17.2	15.2	16.6	20.8	23.5	17.2	11.2	14.6	11.3	9.1	16.0	96.8	6.5	39.6
* G	1.1	9.9	14.5	24.5	19.1	16.9	19.7	23.8	26.7	19.1	13.3	15.5	13.4	10.0	18.0	114.9	7.4	47.0
H	0.1	9.5	1.2	2.3	1.1	1.1	1.2	2.3	2.4	1.2	1.3	1.3	1.3	1.4	1.5	116.4	0.6	47.6
* I	1.6	9.4	20.6	33.7	25.8	22.6	26.6	33.8	36.2	27.5	17.4	21.8	17.4	14.3	24.7	141.1	10.1	57.7
J	0.2	9.1	1.9	3.0	2.4	2.1	2.4	3.0	3.3	2.4	1.6	2.0	1.6	1.3	2.3	143.4	0.9	58.6
* K	0.5	9.1	6.0	9.6	8.4	7.4	8.8	9.8	11.1	7.8	6.1	7.1	6.0	3.9	7.7	151.1	3.1	61.7
* L	0.4	8.9	4.9	7.6	6.2	5.8	6.2	7.8	9.2	6.6	5.0	5.2	5.0	3.6	6.1	157.1	2.5	64.2
* M	0.6	8.6	8.1	12.5	10.1	8.8	10.3	11.7	13.0	9.6	7.3	8.6	7.3	6.0	9.4	166.6	3.9	68.1
N	0.2	8.2	1.8	2.8	2.2	1.9	2.2	2.7	3.0	2.2	1.5	1.8	1.5	1.1	2.1	168.6	0.8	68.9
* O	1.1	8.1	13.7	21.8	17.0	14.8	16.4	21.0	22.7	17.0	11.2	14.5	11.2	9.3	15.9	184.5	6.5	75.4
* P	0.8	7.9	12.0	18.3	13.9	12.6	14.5	18.5	17.0	14.9	10.2	11.5	10.2	7.6	13.4	198.0	5.5	80.9
* Q	0.8	7.6	9.1	13.6	11.6	9.9	10.7	13.7	15.5	11.8	6.9	9.6	8.0	5.5	10.4	208.4	4.3	85.2
R	0.7	7.1	6.1	9.5	7.7	6.5	7.7	9.5	10.4	7.6	5.1	6.4	5.2	4.0	7.1	215.5	2.9	88.1
S	0.3	6.8	4.1	6.4	5.1	4.3	5.2	6.3	7.1	5.1	3.5	4.2	3.5	2.7	4.8	220.3	2.0	90.0
T	0.2	6.7	2.7	4.3	3.4	2.9	3.4	4.3	4.7	3.4	2.3	2.9	2.4	1.8	3.2	223.5	1.3	91.4
U	0.9	5.9	9.1	14.1	11.4	9.6	11.4	14.0	15.6	11.3	7.6	9.4	7.8	5.9	10.6	234.1	4.3	95.7
V	1.0	5.6	9.1	14.1	11.3	9.5	11.4	14.0	15.5	11.3	7.6	9.2	7.7	5.8	10.5	244.7	4.3	100.0
MEAN TOTAL	19.1		267.0	328.0	260.0	226.0	262.0	324.0	359.0	241.0	176.0	218.0	180.0	140.0	244.7		100.0	

* - DENOTES BASINS SUBJECT TO PROJECT DIVERSION
** - DENOTES DIVERSIONS SUBJECT TO CONTINUOUS MINIMUM BY-PASS FLOWS

TABLE B-6b-5

DATE: 09/01/86

HANALEI RIVER HYDROELECTRIC PROJECT
DRAINAGE BASIN ANALYSIS

COMBINED FLOWS OF
USGS STATION # 16102000 - (CHINA DITCH)
YEARS (1915-1919)
USGS STATION # 16103000 LATITUDE 22 11 31 LONGITUDE 159 27 57
YEARS (1964-1984)
TOTAL MEAN ANNUAL FLOW - 244.7 CFS

MEAN MONTHLY FLOW SUMMARY
PROJECT CONDITION
FLOW REMAINING IN CHANNEL

DRAINAGE AREA 19.1 SQ. MI.

DATUM 35.0

BASIN	AREA	ELV. MI	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	MEAN	ACCUM. FLOW	% TOTAL FLOW	ACCUM. % FLOW
* ** A,B	0.0	11.1	11.5	27.3	16.4	12.0	17.8	27.3	27.8	16.1	13.1	10.3	11.8	10.0	16.8	16.8	6.9	6.9
C	0.2	11.0	2.5	3.6	2.5	2.5	2.5	3.6	3.6	2.5	1.3	2.5	1.3	1.3	2.5	19.2	1.0	7.9
D	0.2	10.7	2.6	3.7	2.6	2.6	2.6	3.7	3.7	2.6	1.4	2.6	1.4	1.4	2.6	21.8	1.1	8.9
E	0.4	10.5	4.5	7.9	6.0	5.7	5.8	7.9	7.9	5.7	3.4	4.5	3.4	3.4	5.6	27.5	2.3	11.2
* F	0.2	10.3	4.0	10.5	6.5	4.3	6.4	10.4	12.3	5.5	2.5	3.6	2.0	1.4	5.8	33.2	2.4	13.6
* G	0.3	9.9	2.7	8.7	4.9	5.5	5.2	8.6	8.9	4.7	4.0	2.4	2.3	0.9	4.9	38.1	2.0	15.6
H	0.1	9.5	1.2	2.4	1.2	1.2	1.2	2.4	2.4	1.2	1.2	1.2	1.2	1.2	1.5	39.6	0.6	16.2
* I	0.7	9.4	6.4	15.9	10.2	7.7	10.4	15.6	16.0	9.9	5.6	6.0	4.9	3.5	9.3	49.0	3.8	20.0
J	0.2	9.1	1.9	3.0	2.4	2.1	2.4	3.0	3.3	2.4	1.6	2.0	1.6	1.3	2.3	51.2	0.9	20.9
* K	0.1	9.1	1.1	2.4	1.6	1.2	1.7	2.6	2.6	1.4	1.3	1.0	1.0	0.0	1.5	52.7	0.6	21.5
* L	0.2	8.9	1.7	4.1	2.9	1.0	2.8	4.3	4.4	2.7	1.5	1.6	1.3	0.9	2.5	55.2	1.0	22.6
* M	0.2	8.6	1.6	3.9	2.5	1.7	2.5	2.8	4.0	2.3	1.5	1.5	1.2	0.9	2.2	57.4	0.9	23.5
N	0.2	8.2	1.8	2.9	2.3	2.0	2.3	2.8	3.0	2.2	1.4	1.7	1.4	1.0	2.1	59.5	0.8	24.3
* O	0.5	8.1	3.7	7.9	5.4	4.7	5.4	8.3	8.2	5.1	2.9	3.6	2.5	2.5	5.0	64.5	2.0	26.4
* P	0.2	7.9	2.3	6.9	4.0	2.4	4.1	6.7	3.8	3.6	2.0	1.9	1.6	1.0	3.4	67.9	1.4	27.7
* Q	0.3	7.6	2.5	6.1	4.0	2.0	4.0	5.9	6.4	3.7	2.2	2.4	1.9	1.4	3.6	71.5	1.5	29.2
R	0.7	7.1	6.1	9.5	7.7	6.5	7.7	9.5	10.4	7.6	5.1	6.4	5.2	4.0	7.1	78.6	2.9	32.1
S	0.3	6.8	4.1	6.4	5.1	4.3	5.2	6.3	7.1	5.1	3.5	4.2	3.5	2.7	4.8	83.4	2.0	34.1
T	0.2	6.7	2.7	4.3	3.4	2.9	3.4	4.3	4.7	3.4	2.3	2.9	2.4	1.8	3.2	86.6	1.3	35.4
U	0.9	5.9	9.1	14.1	11.4	9.6	11.4	14.0	15.6	11.3	7.6	9.4	7.8	5.9	10.6	97.2	4.3	39.7
V	1.0	5.6	9.1	14.1	11.3	9.5	11.4	14.0	15.5	11.3	7.6	9.2	7.7	5.8	10.5	107.8	4.3	44.0
	7.0	MEAN TOTAL	83.1	165.5	115.1	93.0	117.2	164.0	171.5	110.3	73.0	80.9	67.4	52.3	107.8		44.0	

* - DENOTES BASINS SUBJECT TO PROJECT DIVERSION
** - DENOTES DIVERSIONS SUBJECT TO CONTINUOUS MINIMUM BY-PASS FLOWS

TABLE B-6b-6

DATE: 09/01/86

HANALEI RIVER HYDROELECTRIC PROJECT
DRAINAGE BASIN ANALYSIS

MEAN ANNUAL FLOW COMPARISON
PROJECT CONDITION
FLOW DISTRIBUTION SUMMARY

MEAN ANNUAL FLOW (CFS)

USGS STATION # 16102000 - (CHINA DITCH)
YEARS (1915-1919)
USGS STATION # 16103000 LATITUDE 22 11 31 LONGITUDE 159 27 57 DRAINAGE AREA 19.1 SQ. MI. DATUM 35.8
YEARS (1964-1984)
TOTAL MEAN ANNUAL FLOW - 244.7 CFS

			FLOWS UTILIZED BY PROJECT		FLOWS NOT UTILIZED BY PROJECT						
			FLOWS DIVERTED FOR PROJECT		FLOWS EXCEEDING DIV. CAPACITY	UNCOLLECTABLE FLOWS	ACCUM. FLOW NOT USED				
BASIN	AREA	RIV. MI	BASIN FLOW	ACCUM. FLOW	BASIN FLOW	BASIN FLOW	ACCUM. FLOW	MEAN	ACCUM. FLOW	% TOTAL FLOW	ACCUM. % FLOW
* ** A,B	6.8	11.1	53.4	53.4	*** 16.8	0.0	16.8	70.1	70.1	28.7	28.7
C	0.2	11.0	0.0	53.4	0.0	2.5	19.2	2.5	72.6	1.0	29.7
D	0.2	10.7	0.0	53.4	0.0	2.6	21.8	2.6	75.2	1.1	30.7
E	0.4	10.5	0.0	53.4	0.0	5.6	27.5	5.6	80.8	2.3	33.0
* F	1.1	10.3	10.2	63.6	3.3	2.5	33.2	16.0	96.9	6.5	39.6
* G	1.1	9.9	13.2	76.8	1.9	3.0	38.1	18.0	114.9	7.4	47.0
H	0.1	9.5	0.0	76.8	0.0	1.5	39.6	1.5	116.4	0.6	47.6
* I	1.6	9.4	15.4	92.2	2.1	7.2	49.0	24.7	141.1	10.1	57.7
J	0.2	9.1	0.0	92.2	0.0	2.3	51.2	2.3	143.4	0.9	58.6
* K	0.5	9.1	6.2	98.4	0.6	0.9	52.7	7.7	151.1	3.1	61.7
* L	0.4	8.9	3.6	101.9	0.8	1.7	55.2	6.1	157.2	2.5	64.2
* M	0.6	8.6	7.2	109.2	0.6	1.6	57.4	9.4	166.6	3.9	68.1
N	0.2	8.2	0.0	109.2	0.0	2.1	59.5	2.1	168.7	0.8	68.9
* O	1.1	8.1	10.9	120.1	0.8	4.2	64.5	15.9	184.5	6.5	75.4
* P	0.8	7.9	10.1	130.1	1.3	2.1	67.9	13.4	198.0	5.5	80.9
* Q	0.8	7.6	6.8	136.9	0.9	2.7	71.5	10.4	208.4	4.3	85.2
R	0.7	7.1	0.0	136.9	0.0	7.1	78.6	7.1	215.6	2.9	88.1
S	0.3	6.8	0.0	136.9	0.0	4.8	83.4	4.8	220.4	2.0	90.1
T	0.2	6.7	0.0	136.9	0.0	3.2	86.6	3.2	223.6	1.3	91.4
U	0.9	5.9	0.0	136.9	0.0	10.6	97.2	10.6	234.2	4.3	95.7
V	1.0	5.6	0.0	136.9	0.0	10.5	107.8	10.5	244.7	4.3	100.0
	19.1	MEAN TOTAL	136.9		29.1	78.7		244.7		100.0	

* - DENOTES BASINS SUBJECT TO PROJECT DIVERSION
** - DENOTES DIVERSIONS SUBJECT TO CONTINUOUS MINIMUM BY-PASS FLOWS
*** - INCLUDES A 10 CFS CONTINUOUS MINIMUM BY-PASS FLOW

TABLE B-6b-7

TABLE B-6b-8

Sub-basin	River Mile	Mean Annual Flow (cfs)	Maximum Diversion Flow (cfs)
A,B	11.1	70.1	106
F	10.3	16.0	13
G	9.9	18.0	21
I	9.4	24.7	24
K	9.1	7.7	11
L	8.9	6.1	5
M	8.6	9.4	12
O	8.1	15.9	20
P	7.9	13.4	15
Q	7.6	10.4	11
	TOTAL	191.7	238

FLOW DURATION

Information from two USGS stream gaging stations were used to construct flow duration information for this study. The two stations were Station 16101000, Hanalei River at altitude 625 and Station 16103000, Hanalei River near Hanalei. The respective drainage areas are 7.17 and 19.1 square miles. Station 16101000 has 41 years of daily flow valu~s available from 1914 to 1955 with missing data for year 1952. Station 16103000 has 30 years of daily flow values available from 1912 to 1919 and 1963 to current. Flow duration tables for Stations 16101000 and 16103000 are shown on Table B-6b-9 and Table B-6b-10 respectively. Flow duration curves are shown on Figure B-3 and Figure B-4.

DIVERSION AND POWERHOUSE SITE SELECTION

In the preliminary screening of sites for the relative location of diversion and powerplant, an inspection of the topography, the constructability and the relationship of discharge and differences in elevation were analyzed. The diversion site was selected using two major criteria: first, in maximizing the amount of head for power production; second, in maximizing the amount of flow for power production. In order to capture the maximum amount of flow, the diversion was located at the confluence of the Hanalei River and Kaapoka Stream. This site allows for the maximum amount of power head available while maintaining a significant amount of flows for power production. The powerhouse site was selected at the lowest possible elevation in order to maximize the amount of power head. However, the powerhouse had to be located upstream of the China Ditch and Kuna Ditch diversions as not to impact the existing use of irrigation flows. Further, the State Department of Forestry is planning future development in the area above the China Ditch Diversion. The powerhouse was located just upstream from this planned development to avoid conflicts with forestry plans.

LOW FLOW FREQUENCY ANALYSIS

In order to determine the frequency of low flows at the location of the main diversion weir, the historic flow records were analized for USGS Station 16101000 which is located near the diversion site. The lowest amount of flow measured at this station was 10 cfs, which occured several times during the period of record. Flows in the range of 11-15 cfs have been measured frequently and have occured for several consecutive days at a time. The flow duration table for USGS Station 16101000 (Table B-6b-9) further indicates that flows in excess of 10 cfs do not occur 100% of the time at this site.

Table B-6b-11 lists several low flow measurements which have been recorded at USGS Station 16101000 over the period of record.

MINIMUM BY-PASS FLOWS

Determination of an adequate continuous minimum by-pass flow for the main diversion weir was made utilizing the flow duration information discussed in the previous section (Low Flow Frequency Analysis). Since flows in excess of 10 cfs do not occur 100% of the time under natural conditions, 10 cfs was selected for use in this study.

GAINING NATURE OF HANALEI RIVER

A substantial amount of the flow in the Hanalei River is contributed by the numerous sub-basins occuring between the proposed main diversion weir (near USGS Station 16101000) and the proposed powerhouse location (near USGS Station 16103000). These inflows will act to enhance the continuous minimum flow by-passed at the main diversion weir. Table B-6b-12 and Table B-6b-13 to depict the gaining nature of the Hanalei River between stations 16101000 and station 16103000 respectively during low flow and high flow occurances.

FLOOD FREQUENCY ANALYSIS

A flood frequency analysis for the Hanalei River at USGS Station 16103000 was performed to assist in the alignment and placement of the major project components. Several formulas were used in the flood analysis including Log Pearson Type III Distribution, Log Pearson Normal Distribution, Rank Method, Log T Distribution and Gumbles Extreme Value Theorem. By comparison, the Log T Distribution formula yielded the greatest amount of flow for each perspective period of time. In order to avoid the failure or loss of the various project features, the 200 year flood value of 11,800 cfs was selected and the water surface profile was plotted on the penstock plan and profile drawings. The project components which are to be above ground were then placed above the water surface elevation which was identified. Table B-6b-14 summarizes the results of the Log T distribution formula used in this analysis.

FLOW DURATION TABLE STA.#16101000

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
10	100.00	11	99.97	12	99.66	13	99.12
14	98.17	15	96.72	16	94.93	17	93.72
18	91.51	19	89.84	20	87.25	21	85.28
22	83.53	23	81.26	24	79.79	25	78.05
26	76.48	27	74.63	28	73.47	29	71.91
30	70.43	31	69.04	32	67.70	33	66.04
34	65.56	35	64.16	36	63.64	37	62.16
38	60.69	39	60.40	40	58.92	41	57.79
42	57.56	43	56.10	44	54.67	45	54.30
46	53.20	47	51.42	48	51.22	49	50.10
50	49.78	51	48.05	52	47.33	53	47.08
54	44.91	55	43.88	56	43.71	57	42.59
58	41.11	59	40.98	60	39.66	61	38.54
62	38.31	63	36.82	65	35.89	67	34.78
68	33.48	70	32.28	71	31.70	73	30.28
74	29.59	76	28.25	77	27.78	79	26.71
80	26.20	82	25.54	84	24.80	85	23.92
87	23.18	88	22.57	90	22.12	91	21.50
93	20.90	94	19.85	96	19.50	97	19.04
99	18.72	101	18.09	102	17.60	104	17.18
105	16.94	107	16.63	108	16.42	110	15.76
111	15.55	113	15.28	114	15.09	116	14.84
118	14.58	119	14.12	121	13.91	122	13.63
124	13.21	125	12.88	127	12.73	128	12.39
130	12.23	131	12.03	133	11.92	135	11.66
136	11.44	138	11.14	139	10.94	141	10.73
142	10.61	144	10.34	145	10.22	147	9.99
149	9.81	150	9.65	152	9.55	153	9.50
155	9.40	156	9.21	158	9.11	159	8.85
161	8.73	162	8.64	164	8.58	166	8.46
167	8.38	169	8.31	170	8.20	172	7.89
173	7.80	175	7.66	176	7.58	178	7.46
179	7.39	181	7.31	183	7.22	184	7.04
186	6.95	187	6.83	189	6.76	190	6.67
192	6.61	193	6.51	195	6.47	196	6.32
198	6.29	200	6.17	201	6.08	203	5.99
204	5.93	206	5.88	207	5.84	209	5.76
210	5.69	212	5.66	213	5.56	215	5.49
217	5.48	218	5.41	220	5.38	221	5.33
223	5.25	224	5.21	226	5.19	227	5.14
229	5.09	231	4.98	232	4.95	234	4.88
235	4.85	237	4.77	238	4.66	240	4.66
241	4.61	243	4.60	244	4.56	246	4.51
248	4.50	249	4.43	251	4.42	252	4.34
254	4.31	255	4.28	257	4.27	258	4.25
260	4.20	261	4.12	263	4.08	265	4.01
266	3.99	268	3.92	269	3.89	271	3.86
272	3.83	274	3.82	275	3.80	277	3.75
278	3.73	280	3.70	282	3.67	283	3.63
285	3.58	288	3.57	289	3.53	291	3.48

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
292	3.47	294	3.45	295	3.38	297	3.36
299	3.33	300	3.31	302	3.26	303	3.22
305	3.21	306	3.18	308	3.14	309	3.12
311	3.04	312	3.00	314	2.99	316	2.96
317	2.93	319	2.90	320	2.89	322	2.88
323	2.85	325	2.82	326	2.81	328	2.80
330	2.73	331	2.71	333	2.68	334	2.64
336	2.59	337	2.57	339	2.56	340	2.54
342	2.53	343	2.52	345	2.49	347	2.48
348	2.41	350	2.39	351	2.37	353	2.36
354	2.32	356	2.31	357	2.30	359	2.30
360	2.28	362	2.26	364	2.25	365	2.23
367	2.18	368	2.16	371	2.15	373	2.13
374	2.13	376	2.11	377	2.11	379	2.10
381	2.08	382	2.07	384	2.06	385	2.05
387	2.03	388	1.98	390	1.97	391	1.96
393	1.92	394	1.91	396	1.90	398	1.89
401	1.89	402	1.88	404	1.87	405	1.86
407	1.82	410	1.82	413	1.81	415	1.79
418	1.79	419	1.78	421	1.76	422	1.75
425	1.74	427	1.73	429	1.71	435	1.70
438	1.68	439	1.67	441	1.67	444	1.65
446	1.65	449	1.63	453	1.61	456	1.60
459	1.59	461	1.58	463	1.57	464	1.56
466	1.53	467	1.52	469	1.51	470	1.49
472	1.48	473	1.47	475	1.46	478	1.46
480	1.44	481	1.43	483	1.41	484	1.39
487	1.38	489	1.37	490	1.36	492	1.34
495	1.33	497	1.31	498	1.31	507	1.29
509	1.28	511	1.26	517	1.26	518	1.25
520	1.23	523	1.22	524	1.19	526	1.18
529	1.12	531	1.11	532	1.10	537	1.09
538	1.07	540	1.06	541	1.05	545	1.04
546	1.02	548	1.01	549	1.00	554	1.00
555	.99	557	.98	560	.96	563	.95
566	.94	568	.93	572	.93	574	.90
575	.89	580	.88	588	.86	596	.85
600	.84	603	.83	605	.79	616	.78
619	.78	623	.76	625	.74	627	.73
630	.72	633	.71	634	.71	642	.69
647	.68	659	.67	665	.66	667	.65
668	.64	673	.64	674	.63	676	.62
681	.61	684	.61	685	.60	688	.59
690	.59	696	.58	698	.57	702	.57
707	.56	715	.55	719	.54	722	.53
724	.52	727	.52	739	.51	743	.49
744	.48	749	.47	758	.47	760	.45
772	.44	778	.43	781	.42	784	.41
792	.40	829	.40	835	.39	838	.38
848	.37	874	.37	882	.36	883	.35

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
894	.35	897	.34	900	.33	903	.33
905	.32	907	.31	913	.30	928	.29
936	.28	961	.28	967	.27	978	.26
984	.25	993	.25	1010	.24	1040	.23
1050	.23	1140	.22	1160	.21	1170	.19
1180	.18	1190	.18	1200	.16	1230	.16
1240	.15	1290	.13	1300	.11	1330	.11
1380	.09	1410	.08	1450	.08	1540	.06
1550	.06	1560	.05	1620	.04	1640	.04
1750	.03	2060	.02	3480	.01	4440	.01

FLOW DURATION TABLE STA.#16103000

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
31	100.00	32	99.99	33	99.93	34	99.86
35	99.79	36	99.50	37	99.39	38	99.22
39	99.03	40	98.92	41	98.60	42	98.44
43	98.08	44	97.77	45	97.37	46	97.06
47	96.44	48	96.15	49	95.74	50	95.27
51	94.76	52	94.40	53	93.61	54	93.13
55	92.37	56	91.87	57	91.06	58	90.48
59	89.69	60	89.15	61	88.33	62	87.72
63	86.40	64	85.80	65	85.15	66	84.50
67	83.87	68	83.12	69	82.30	70	81.85
71	80.82	72	80.29	73	79.68	74	79.09
75	78.41	76	77.94	77	77.11	78	76 05
79	75.42	80	74.85	81	73.80	82	73.48
83	72.75	84	72.49	85	71.70	86	71.19
87	70.52	88	69.78	89	68.85	90	68.62
91	66.92	92	66.57	93	66.02	94	64.27
95	63.89	96	63.51	97	62.81	98	62.45
99	62.04	100	61.51	101	60.52	102	60.40
103	59.24	104	58.87	105	58.55	106	58.05
107	57.68	108	57.28	109	56.95	110	56.58
111	55.65	112	55.15	113	54.83	114	54.32
115	53.88	116	53.61	117	53.21	118	52.88
119	52.12	120	51.80	121	51.20	122	50.94
123	50.75	124	50.42	125	48.03	126	47.79
127	47.57	128	47.08	129	46.73	130	46.52
131	45.47	132	45.39	133	44.68	134	44.51
135	44.34	136	44.07	137	43.57	138	43.31
139	43.14	140	42.63	141	42.30	142	42.06
143	41.52	144	41.32	145	41.15	146	41.03
147	40.93	148	40.44	149	40.29	150	40.14
151	39.28	152	39.07	153	38.74	154	38.60
155	38.52	156	37.35	157	37.29	158	37.21
159	36.64	160	36.52	161	36.18	162	36.05
163	35.75	164	35.67	165	35.56	166	35.40
167	35.27	168	35.00	169	34.82	170	34.43
171	33.95	172	33.77	173	33.60	174	33.33
175	33.28	176	33.09	177	32.95	178	32.81
179	32.21	180	32.08	181	31.74	182	31.50
183	31.45	184	31.08	185	30.99	186	30.89
187	30.41	188	30.25	189	30.14	190	29.98
191	29.80	192	29.71	193	29.61	194	29.50
195	29.46	196	29.26	197	29.17	198	29.12
199	28.79	200	28.74	201	27.81	202	27.32
203	27.11	204	27.09	205	26.96	206	26.81
207	26.76	208	26.54	209	26.49	210	26.35
211	26.20	212	26.13	213	26.10	214	26.05
215	26.00	216	25.83	217	25.79	218	25.46
219	25.37	220	25.28	221	24.92	222	24.83
223	24.79	224	24.45	225	24.37	226	24.31
227	24.23	228	24.17	229	24.12	230	23.54

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
231	23.34	232	23.16	233	22.98	234	22.93
235	22.86	236	22.77	237	22.72	238	22.69
239	22.60	240	22.57	241	22.18	242	22.05
243	21.99	244	21.87	245	21.84	246	21.81
247	21.71	248	21.69	249	21.55	250	21.53
251	21.11	252	20.91	253	20.79	254	20.75
255	20.45	256	20.19	257	20.13	258	20.07
259	20.04	260	20.02	261	19.96	262	19.91
263	19.87	264	19.63	265	19.60	266	19.56
267	19.49	268	19.48	269	19.44	270	19.39
271	19.30	272	19.27	273	19.21	274	19.15
275	19.04	276	18.98	277	18.94	278	18.89
279	18.55	280	18.52	281	18.45	282	18.42
283	18.38	284	18.33	285	18.28	286	18.26
287	18.08	288	18.01	289	17.96	290	17.93
291	17.81	292	17.68	293	17.63	294	17.60
295	17.52	296	17.49	297	17.45	298	17.41
299	17.36	300	17.32	301	17.06	302	17.05
303	16.97	304	16.93	305	16.91	306	16.86
307	16.81	308	16.75	309	16.70	310	16.38
311	16.26	312	16.24	313	16.20	314	16.17
315	16.14	316	16.12	317	16.09	318	15.78
319	15.74	320	15.69	321	15.66	322	15.65
323	15.55	324	15.50	325	15.46	326	15.39
327	15.37	328	15.33	329	15.29	330	15.25
331	15.13	332	15.08	333	15.05	334	15.01
335	14.93	336	14.92	337	14.91	338	14.85
339	14.82	340	14.77	341	14.50	342	14.48
343	14.44	344	14.43	345	14.42	346	14.39
347	14.37	348	14.31	349	14.09	350	14.06
351	13.85	352	13.83	353	13.82	354	13.73
356	13.69	357	13.64	358	13.61	359	13.60
360	13.57	361	13.52	362	13.49	363	13.44
364	13.43	365	13.30	366	13.27	367	13.26
368	13.24	369	13.23	370	13.21	371	13.13
372	13.12	373	13.08	374	13.04	375	13.00
376	12.99	377	12.95	378	12.94	379	12.91
380	12.52	381	12.49	382	12.43	383	12.41
384	12.40	385	12.38	386	12.37	387	12.36
388	12.26	389	12.23	390	12.21	391	12.12
393	12.11	394	12.08	396	12.04	397	12.03
398	12.02	399	11.99	400	11.98	401	11.70
402	11.69	403	11.66	405	11.64	406	11.61
407	11.60	408	11.58	409	11.57	410	11.57
411	11.51	412	11.50	413	11.49	414	11.46
415	11.45	417	11.35	418	11.32	419	11.12
420	11.10	421	11.06	422	11.05	423	11.03
424	11.02	425	10.99	426	10.96	427	10.92
428	10.90	429	10.89	430	10.84	432	10.81
433	10.79	434	10.76	435	10.73	437	10.70

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
438	10.68	439	10.66	440	10.61	441	10.60
443	10.56	445	10.56	446	10.55	447	10.54
449	10.53	450	10.39	451	10.29	452	10.28
453	10.25	454	10.23	455	10.22	456	10.20
457	10.02	458	10.01	460	10.00	461	9.97
462	9.96	463	9.94	464	9.90	465	9.86
466	9.81	467	9.78	469	9.74	470	9.73
471	9.71	472	9.69	474	9.64	475	9.61
476	9.60	477	9.57	478	9.55	480	9.54
481	9.52	482	9.50	483	9.46	486	9.43
487	9.40	489	9.26	490	9.23	492	9.22
493	9.20	495	9.17	496	9.02	497	8.99
499	8.97	500	8.96	501	8.79	502	8.78
503	8.77	504	8.71	507	8.70	508	8.69
509	8.68	510	8.65	511	8.64	512	8.61
513	8.59	514	8.57	515	8.56	516	8.54
517	8.53	519	8.50	520	8.49	521	8.45
522	8.41	523	8.38	524	8.35	526	8.32
527	8.16	528	8.13	529	8.12	530	8.09
531	8.07	532	8.06	533	8.05	534	8.04
537	7.97	538	7.95	540	7.93	541	7.88
542	7.86	546	7.85	549	7.84	552	7.83
554	7.82	555	7.81	556	7.80	558	7.79
560	7.78	561	7.76	565	7.74	566	7.67
567	7.64	568	7.63	569	7.60	570	7.59
572	7.58	573	7.45	575	7.44	577	7.43
578	7.41	579	7.40	580	7.39	581	7.36
582	7.35	585	7.30	586	7.29	587	7.28
588	7.26	590	7.25	591	7.23	592	7.22
595	7.21	596	7.20	597	7.19	599	7.18
600	7.18	601	7.05	603	7.04	605	6.93
606	6.89	608	6.88	609	6.87	610	6.85
611	6.84	612	6.83	615	6.82	616	6.81
617	6.79	619	6.74	620	6.60	623	6.58
627	6.57	628	6.56	630	6.54	631	6.53
633	6.52	634	6.50	635	6.49	637	6.48
638	6.46	640	6.44	642	6.42	643	6.40
644	6.39	645	6.38	647	6.37	648	6.34
649	6.33	654	6.33	655	6.32	657	6.31
659	6.30	660	6.29	665	6.28	668	6.17
670	6.16	672	6.14	673	6.13	676	6.12
680	6.10	682	6.07	688	6.03	689	5.95
690	5.94	691	5.93	693	5.92	696	5.91
697	5.89	698	5.87	700	5.86	701	5.75
705	5.74	706	5.71	707	5.70	709	5.69
712	5.67	715	5.59	718	5.57	720	5.56
726	5.55	727	5.54	730	5.51	731	5.45
732	5.44	733	5.42	734	5.41	735	5.40
736	5.37	738	5.36	739	5.35	740	5.33
741	5.31	742	5.30	744	5.28	746	5.25

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
747	5.22	748	5.21	750	5.19	754	5.15
755	5.15	758	5.14	760	5.10	762	5.08
763	5.07	766	5.06	767	5.04	770	5.03
771	4.99	772	4.98	774	4.98	778	4.91
780	4.90	781	4.88	783	4.86	786	4.84
787	4.83	791	4.81	792	4.80	794	4.79
797	4.78	799	4.77	800	4.76	801	4.70
802	4.68	804	4.67	808	4.60	810	4.59
812	4.58	813	4.57	816	4.55	818	4.54
820	4.53	821	4.49	825	4.47	828	4.45
830	4.40	832	4.39	836	4.38	838	4.37
840	4.36	845	4.34	846	4.33	848	4.31
849	4.31	851	4.30	854	4.25	857	4.24
858	4.23	859	4.22	860	4.18	862	4.16
864	4.15	865	4.14	866	4.13	872	4.08
874	4.06	876	4.05	877	4.04	879	4.03
880	4.00	881	3.99	886	3.98	890	3.97
893	3.97	895	3.94	897	3.93	898	3.90
899	3.89	900	3.88	902	3.80	905	3.80
908	3.79	910	3.78	913	3.74	916	3.67
917	3.66	920	3.65	925	3.64	926	3.63
928	3.63	930	3.59	944	3.56	946	3.52
947	3.51	950	3.47	952	3.46	954	3.46
955	3.45	956	3.43	959	3.42	962	3.39
965	3.38	967	3.37	968	3.33	972	3.32
975	3.31	977	3.29	978	3.29	983	3.28
987	3.27	989	3.26	990	3.25	993	3.23
995	3.22	998	3.21	1000	3.18	1010	3.06
1020	3.00	1030	2.96	1040	2.94	1050	2.90
1060	2.81	1080	2.79	1090	2.76	1100	2.73
1110	2.64	1120	2.62	1130	2.58	1140	2.57
1150	2.52	1160	2.47	1170	2.44	1180	2.41
1190	2.38	1200	2.35	1210	2.27	1220	2.24
1230	2.21	1240	2.20	1250	2.14	1260	2.11
1270	2.11	1280	2.08	1300	2.07	1310	2.04
1320	2.02	1330	2.01	1340	2.00	1350	1.99
1360	1.98	1370	1.95	1380	1.94	1390	1.93
1400	1.91	1410	1.89	1430	1.88	1440	1.85
1450	1.83	1470	1.82	1480	1.79	1490	1.77
1500	1.71	1510	1.68	1520	1.65	1540	1.62
1560	1.61	1570	1.58	1560	1.57	1590	1.55
1600	1.51	1610	1.50	1620	1.48	1630	1.46
1640	1.45	1660	1.44	1670	1.44	1680	1.43
1690	1.41	1700	1.39	1710	1.33	1720	1.31
1730	1.29	1750	1.28	1760	1.27	1790	1.24
1800	1.22	1810	1.20	1850	1.15	1860	1.12
1880	1.10	1890	1.08	1920	1.06	1960	1.03
1970	1.02	1980	1.01	2000	.99	2010	.97
2040	.94	2050	.93	2070	.92	2100	.89
2110	.87	2130	.86	2150	.85	2160	.84

FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT	FLOW	PERCENT
2170	.83	2200	.80	2230	.78	2250	.76
2260	.76	2270	.75	2280	.74	2300	.73
2310	.72	2320	.69	2340	.68	2380	.66
2390	.65	2420	.64	2430	.63	2460	.62
2480	.60	2490	.58	2500	.57	2570	.55
2590	.54	2600	.52	2630	.51	2700	.50
2740	.49	2750	.47	2790	.46	2830	.45
2850	.44	2860	.43	2870	.42	2950	.41
3000	.40	3090	.38	3100	.36	3120	.35
3130	.34	3200	.33	3280	.32	3370	.31
3400	.30	3450	.28	3480	.27	3490	.26
3640	.25	3700	.23	3730	.20	3790	.19
3860	.18	3910	.17	4010	.16	4020	.15
4100	.13	4380	.12	4640	.11	4790	.10
5180	.09	5310	.08	5410	.08	5520	.07
5570	.06	5680	.05	5960	.04	7810	.03
8340	.02	9580	.01	0	.00	0	.00

TABLE B-6b-11

LOW FLOW MEASUREMENTS
HANALEI RIVER
USGS STATION 16101000

Date	Flow in CFS
Mar 30, 1926	11
Apr 4, 1926	10
Apr 5, 1926	10
May 3, 1926	11
Nov 23, 1933	12
Feb 26, 1934	12
Mar 21, 1934	11
Apr 1, 1934	11
Feb 21, 1947	12
Feb 24, 1947	11
Mar 1, 1947	12
Mar 15, 1947	11
Oct 17, 1950	12
Nov 6, 1950	11
Nov 13, 1950	10
Nov 16, 1950	10
Jul 10, 1953	13
Aug 1, 1953	13
Sep 7, 1953	11
Oct 5, 1953	12
Oct 10, 1953	11
Oct 27, 1953	11
Nov 3, 1953	12

TABLE B-6b-12

LOW FLOW MEASUREMENTS SHOWING THE GAINING NATURE OF THE HANALEI RIVER

Date	Flow in cfs Station 16101000 (DA=7.17 SQ. MI.)	Flow in cfs Station 16103000 (DA=19.1 SQ. MI.)	%Gain
Feb 28, 1914	51	124	243
Mar 6, 1914	59	209	354
Apr 19, 1914	56	317	566
Nov 30, 1914	57	603	1,058
Jan 24, 1915	57	201	353
Feb 11, 1915	53	178	336
Mar 13, 1915	57	286	502
Mar 14, 1915	53	155	292
Sep 11, 1915	57	286	502
Feb 24, 1916	57	278	488
Mar 22, 1916	50	152	304
Apr 14, 1916	50	130	260
Apr 18, 1916	53	173	326
Sep 7, 1916	57	147	258
May 13, 1917	37	130	351
Jul 1, 1917	37	132	357
Aug 23, 1917	28	124	443
Oct 1, 1917	42	142	338
Nov 18, 1917	42	124	295
Jan 6, 1918	22	116	527
Jan 10, 1918	22	142	645
Oct 18, 1918	46	181	393
Nov 16, 1918	48	190	396
Mar 17, 1919	34	102	300

Note: Station 16101000 is located about 6 river miles upstream of Station 16103000.

TABLE B-6b-13

HIGH FLOW MEASUREMENTS SHOWING THE GAINING NATURE OF THE HANALEI RIVER

Date	Flow in cfs Station 16101000 (DA=7.17 SQ. MI.)	Flow in cfs Station 16103000 (DA=19.1 SQ. MI.)	%Gain
May 3, 1914	399	2,000	501
Jun 22, 1914	124	4,020	3,242
Sep 26, 1914	1,240	9,580	773
Nov 30, 1914	74	1,310	1,770
Dec 3, 1914	379	7,810	2,061
Apr 26, 1915	743	2,480	334
Aug 8, 1915	209	1,010	483
Nov 8, 1915	183	3,280	1,792
Jan 26, 1916	882	2,040	231
May 5, 1916	518	1,320	255
Sep 26, 1916	235	1,490	634
Dec 18, 1916	183	3,790	2,071
Jan 19, 1917	1,450	3,640	251
Mar 15, 1917	719	5,680	790
May 19, 1917	781	2,480	318
Oct 16, 1917	328	4,380	1,335
Mar 12, 1918	1,330	4,100	308
Apr 30, 1918	472	5,570	1,180
May 22, 1918	145	3,730	2,572
Oct 31, 1918	555	1,250	225
Nov 25, 1918	237	5,520	2,329
Dec 10, 1918	563	1,620	288
Mar 12, 1919	138	1,500	1,087

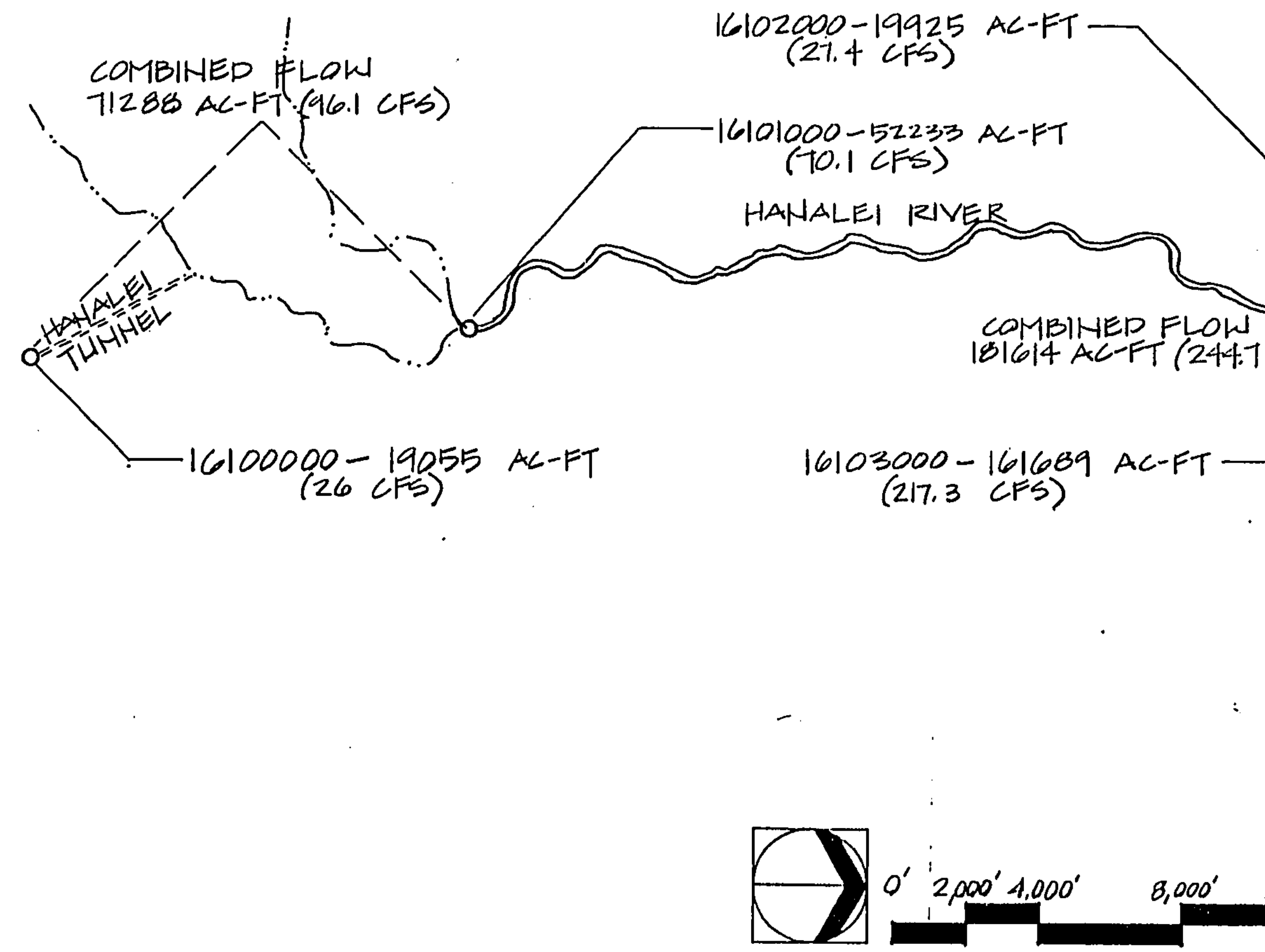
Note: Station 16101000 is located about 6 river miles upstream of Station 16103000.

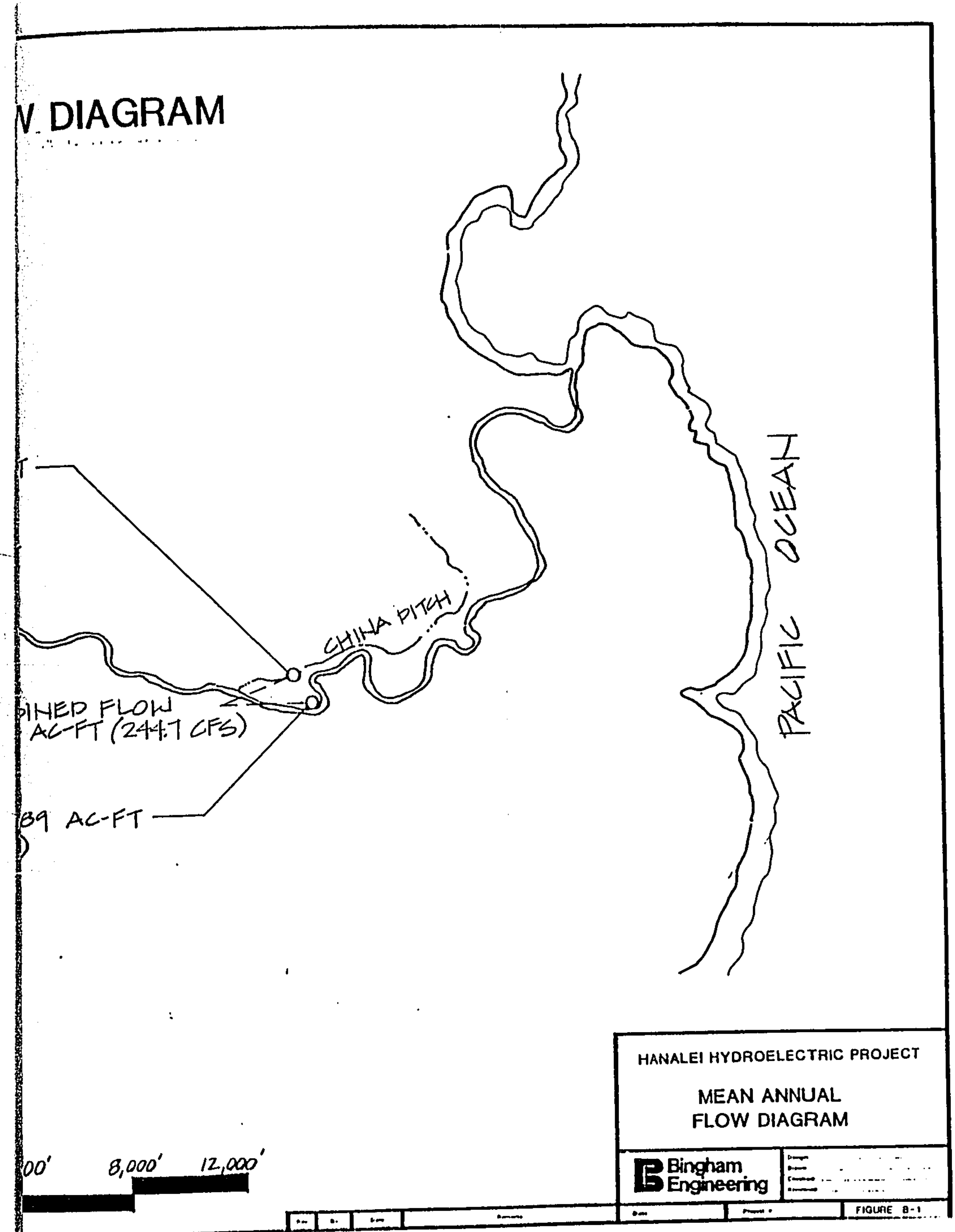
TABLE B-6b-14

HANALEI RIVER AT STATION 16103000
FLOOD FREQUENCY ANALYSIS
LOG T DISTRIBUTION

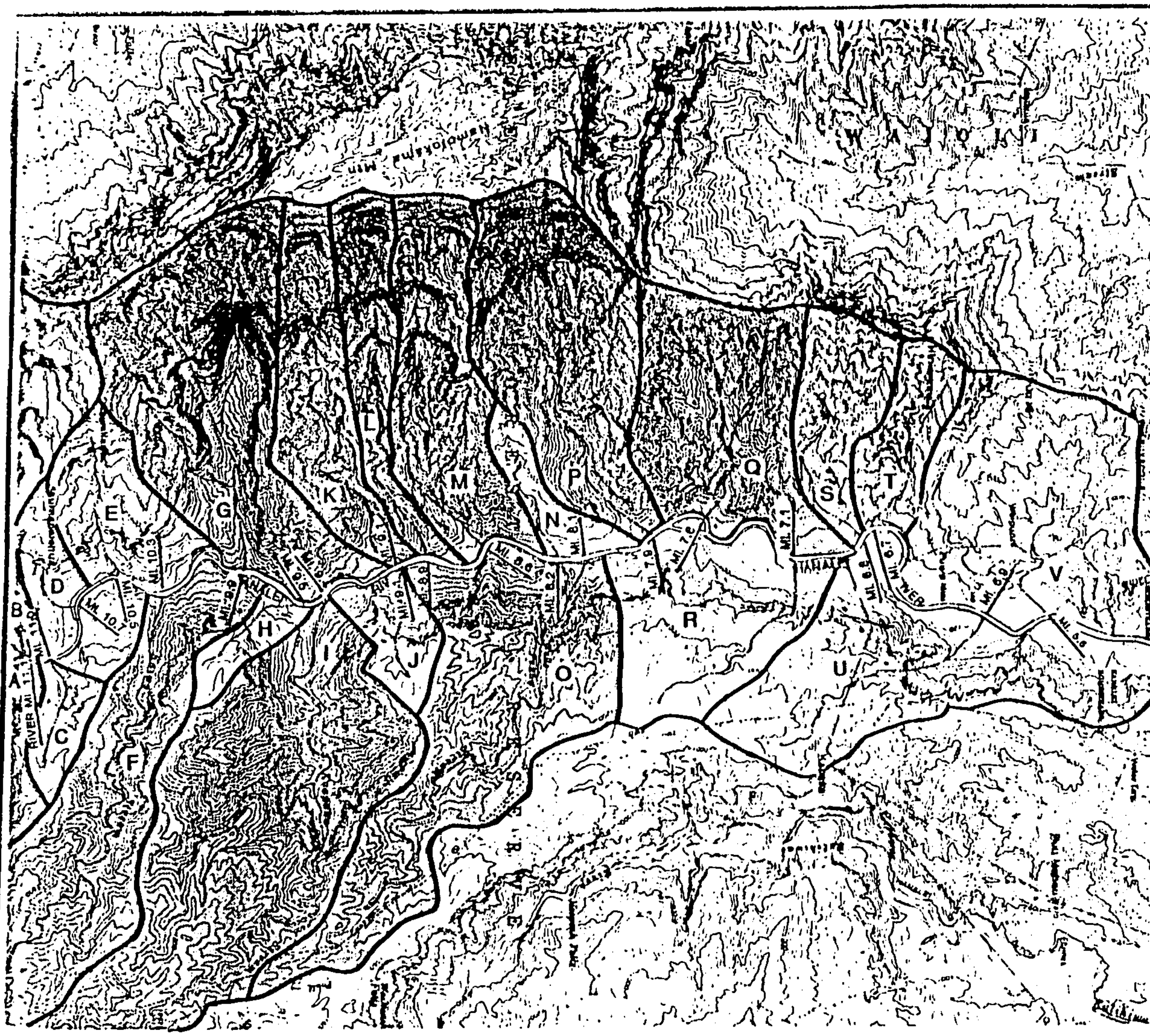
Return Period (Years)	Probability (1%)	Value (cfs)
1.00	99.9	500
1.01	99.0	800
1.11	90.0	1,500
1.25	80.0	1,900
1.33	75.0	2,100
2.00	50.0	2,900
5.00	20.0	4,400
10.00	10.0	5,500
25.00	4.0	7,200
50.00	2.0	8,600
100.00	1.0	10,100
200.00	0.5	11,800
500.00	0.2	14,400
1,000.00	0.1	16,800
10,000.00	0.01	32,000

HANALEI RIVER ANNUAL FLOW DIAGR

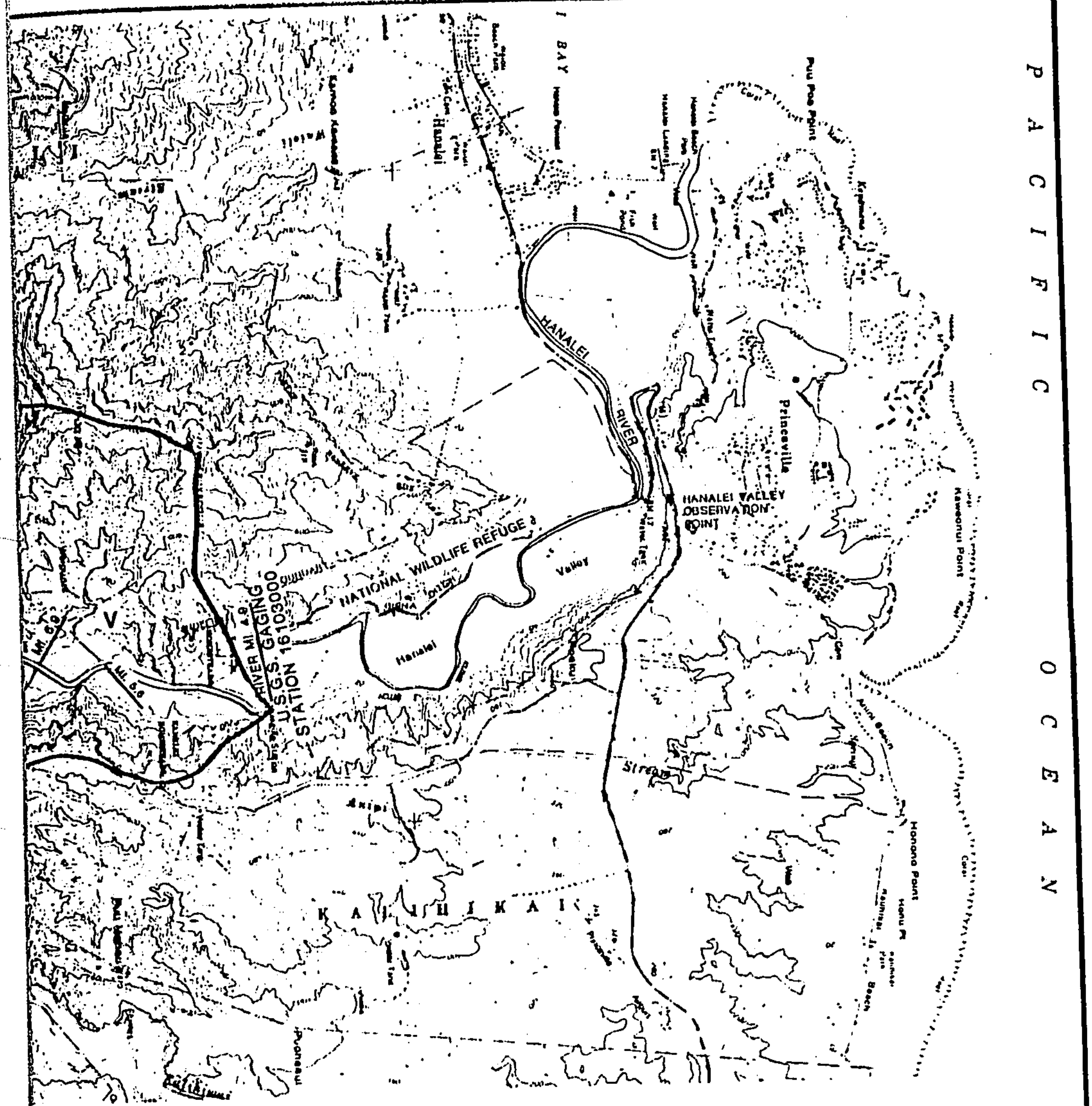


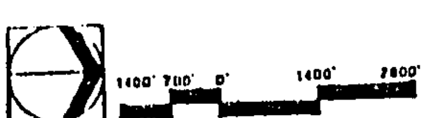


V DIAGRAM
T
CHINA PITCH
INED FLOW
AC-FT (244.7 CFS)
89 AC-FT
PACIFIC OCEAN
00'
8,000'
12,000'
HANALEI HYDROELECTRIC PROJECT
MEAN ANNUAL
FLOW DIAGRAM
Bingham
Engineering
FIGURE 8-1



DIVERTED BASINS





HANALEI HYDROELECTRIC PROJECT

SUB-BASIN IDENTIFICATION AND LOCATION

BINGHAM ENGINEERING

Date March 1986 | Project # 609-014 | FIGURE B-2

HANALEI RIVER
ISLAND POWER COMPANY

Flow Duration Curve U.S.G.S. Sta. 16101000

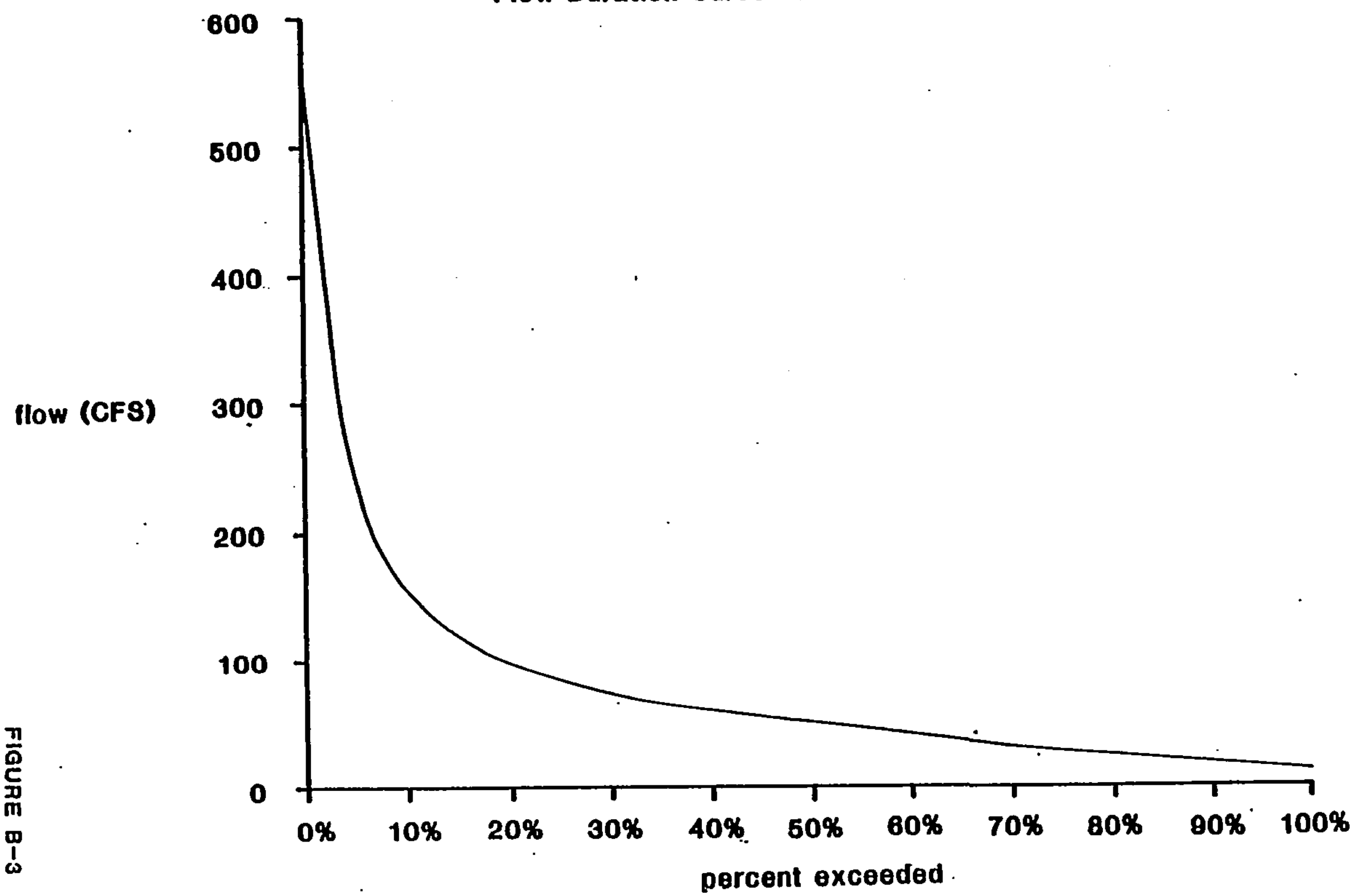


FIGURE B-3

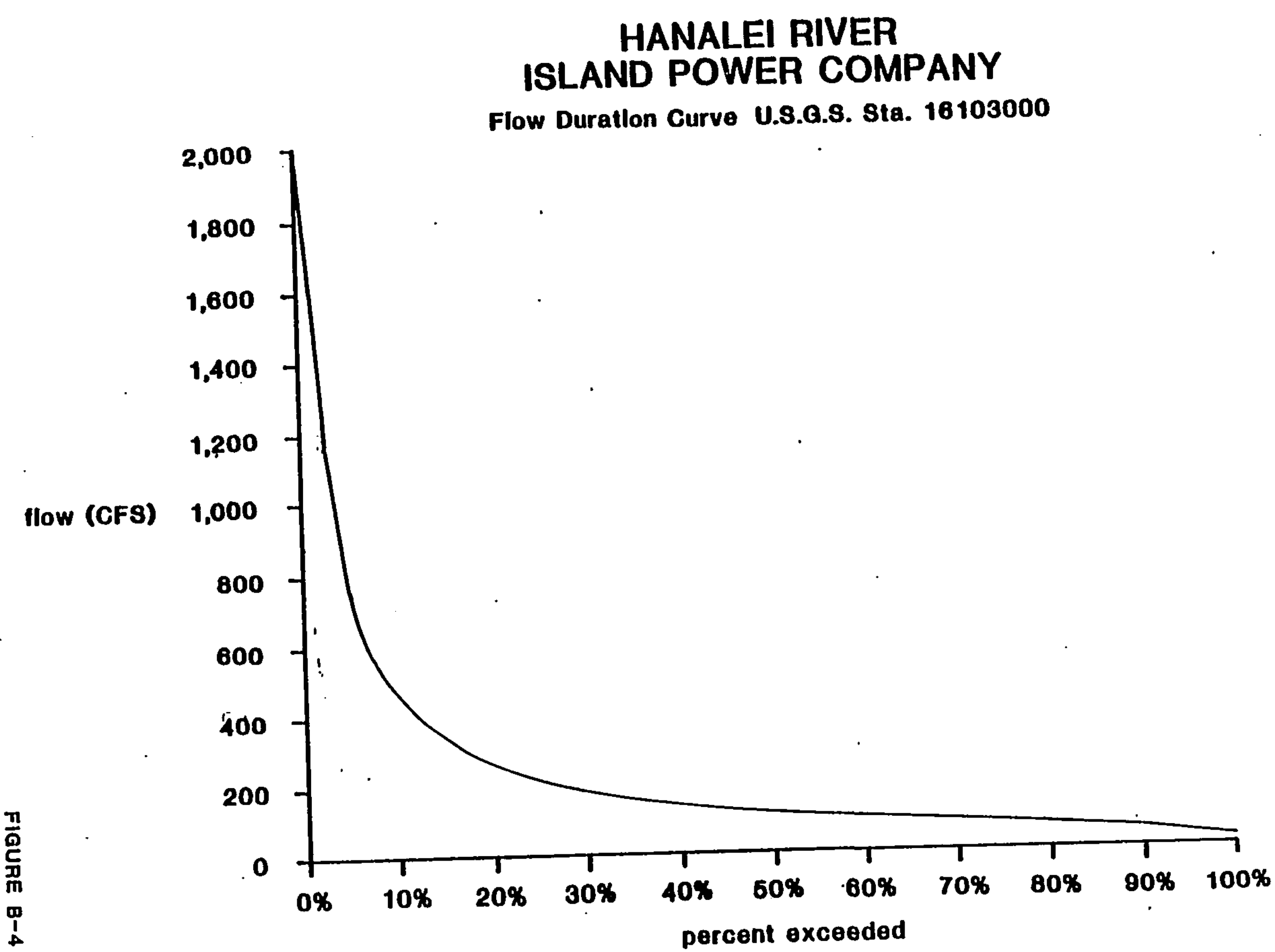

HANALEI RIVER
ISLAND POWER COMPANY
Flow Duration Curve U.S.G.S. Sta. 16103000
flow (CFS)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
percent exceeded

FIGURE B-4

B-6c GEOTECHNICAL INVESTIGATIONS

GEOLOGIC AND ENGINEERING GEOLOGIC RECONNAISSANCE OF THE UPPER HANALEI VALLEY

by

Galen W. Williams, M.S., CPGS

Prepared by

Bingham Engineering
5160 Wiley Post Way
Salt Lake City, UT 84116

December 1986

GEOLOGIC AND ENGINEERING GEOLOGIC RECONNAISSANCE OF THE UPPER HANALEI VALLEY

GEOLOGY AND SOILS

Island Geology

Kauai is structurally the most complicated and one of the oldest of the Hawaiian islands. Basically it is a large shield volcano consisting of thousands of feet of volcanic flows of varying thickness although most are quite thin. The volume is estimated to be on the order of 1,000 cubic miles, the portion of the island above sea level is approximately 555 square miles. Volcanism is most likely Tertiary and was quite rapid. This early stage of activity is called the Waimea Canyon Volcanic Series. Near the end of this build up of flows the summit collapsed creating the largest caldera of any of the Hawaiian Island, averaging 10 - 12 miles.

After this early sequence of rapid volcanics and collapse there was a long period of erosion which allowed a thick soil sequence to develop. Then from a series of about forty vents there was a major period of renewed volcanism. This second series known as the Koloa Volcanic Series resulted in lava filling several of the large depressions along with slope failure of many of the newly developed soils. Some of these lava flows are much thicker in that they were basin fill and therefore not allowed to flow as far and develop into thin flows. Near the Hanalei River this later sequence of flows is evident forcing the channel up against the older Waimea flows re-routing the river to what is now Hanalei Bay.

Although the volcanic sequences described vary somewhat in their cycles and thickness of flows they are quite similar in lithology. They are both basically olivine basalt (calcic plagioclase with pyroxene and magnesium and iron silicate olivines). Numerous variations of these olivine basalts are described in the literature but they are refined igneous petrologic descriptions and do not play a role in siting of the Hanalei project area.

The older Waimea Canyon Series has four members, two of which are located in the project vicinity. The Napali Formation (Twn) is a sequence of thin flows of olivine basalt which accumulated on the flanks of the major sheild volcano. The Olokele Formation (Two) is comprised of thicker flows of olivine basalt with some rare andesites and andesine. These flows accumulated on the broad caldera at the summit of the big shield which explains the thicker sequence. The younger Koloa Volcanic Series has two formations in the project vicinity. The youngest is simply referenced as the Koloa Lava Flows (Qkl) and is a Nepheline (alkali rich) basalt. This flow erupted from several vents along the east side of the island. The more prominent formation is the Palikea Formation (Qkp) which consits of masses of breccia and beds of conglomerates. This formation is in direct contact with the Waimea Series in some places and is intercalated between flows of the Koloa series. The Palikea Formation is considered a sedimentary deposit. All rock units are intruded in several sections by dike swarms and other smaller intrusions. Several dikes were mapped along the intended alignment of the Hanalei project.

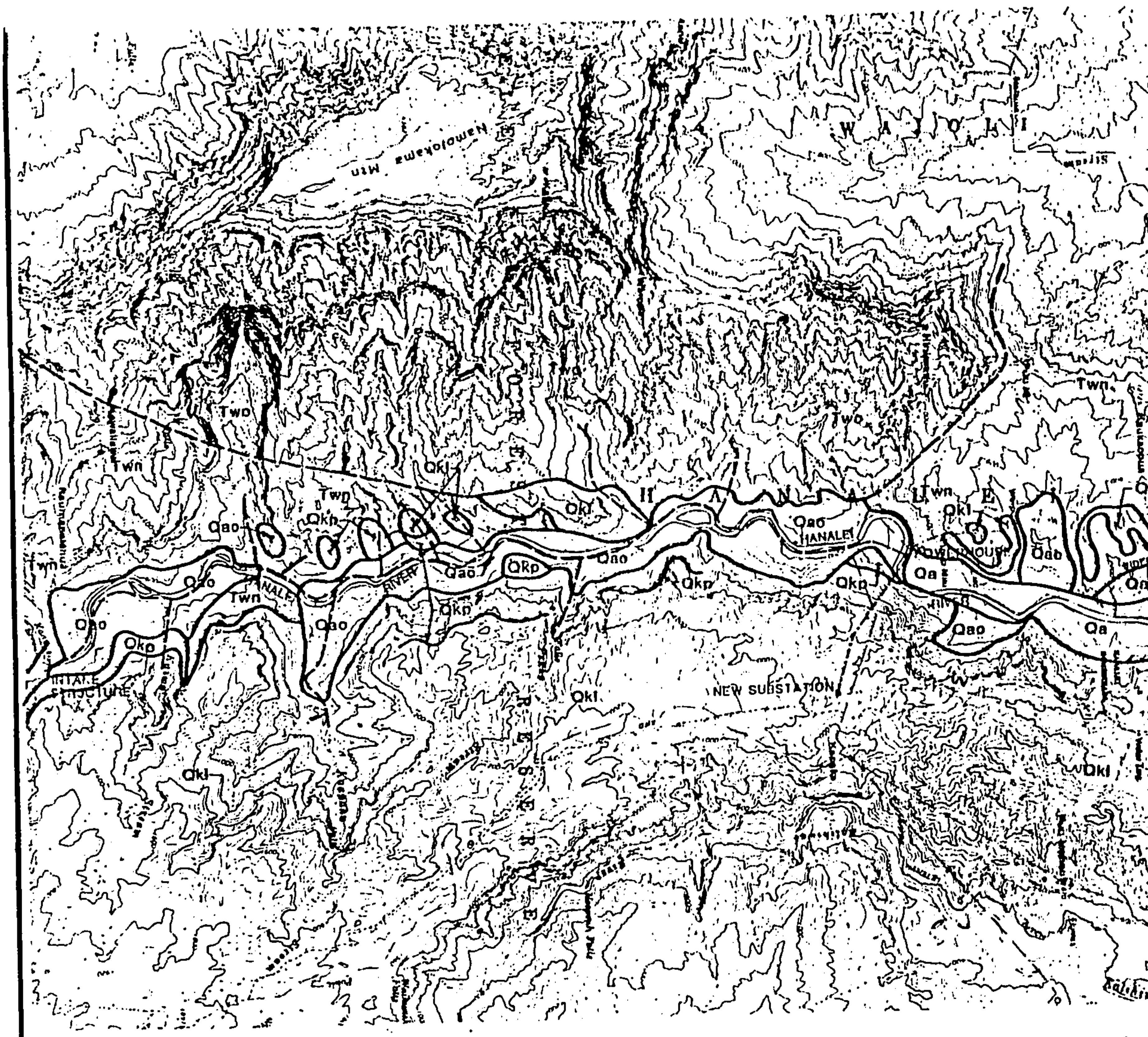
These various rock units and the associated structure are presented on the project vicinity geologic map presented as Figure 1 of this report.

Project Geology

The Hanalei River flows north to the ocean from below Mt. Waialeale. The intended point of diversion is at a point on the river where several smaller tributaries come together and form the larger river section. The Hanalei River flows in a volcanic bedrock controlled channel and has been influenced near its terminus by the later Koloa flows. The Waimea Canyon Volcanics are located to the west forming the higher, steep ridges. The rocks to the east are mostly the Koloa Volcanics and the evidence of this flow in controlling the stream is quite evident. The Koloa flows have advanced from the east and have forced the flow of the river against the Waimea Canyon rocks. This has resulted in a redirection of the terminus of the river and the creation of a new delta environment. Hanalei Bay is the modern terminus west of the older one. Evidence of an older bay is not obvious and may have been partially covered up by the more recent flows.

Seismicity

Earthquakes in the islands are associated with two primary types of activity. By far the most prominent is that associated with the regional ongoing volcanic activity. Although there is no active volcanic process on Kauai, the well known Mauna Loa and Kilauea volcanos on the island of Hawaii display the overall young age and activity of the island system. The earthquake activity associated with the volcanics is definately intermittent. The most significant potential on Kauai is the structural activity associated with the deeper movement along the massive Molokai Fracture Zone within the island environment. This is a major mid-Pacific tectonic feature and the primary siesmic risk for Kauai should be evaluated based on this sytem and not the seismically active sections near the island of Hawaii. As to potential damage and the associated engineering considerations on Kauai there is little in the recent record to use in examining this potential. An event with a Richter magnitude of 7 occured in 1938. This event had an epicenter located on the Molokai Fracture Zone 25 miles north of Pauwela Point on the north shore of Haleakala, Maui. There were no detailed measurements available at that time and therefore the effect on the area around the Hanalei River and the Hanalei Bay cannot be assessed. A Richter magnitude 7.5 event occured along the south coast of the island of Hawaii in 1968 and was caused by more local activity. This, one of the largest events ever recorded in the islands, was associated with local activity near



SEDIMENTS

Qa — Quaternary Alluvium (non-calcareous) Active stream valley alluvium graded to present base level

Qao — Quaternary Alluvium, Older (non-calcareous) Poorly to moderately well consolidated older alluvium, graded to former base level, presently being dissected (correlative with Koloa volcanic series)

KOLOA VOLCANIC SERIES

Qkl — Quaternary Koloa Lavas, Olivine basalts from numerous vents

Qkp — Quaternary Koloa Volcanics, Palikea Formation Breccia intercalated between flows of Koloa series

Thin conglomerate beds of above formation

WAIMEA CANYON VOLCANIC SERIES

Twn — Tertiary Waimea Canyon Volcanics, Napali Formation Thin flows of olivine basalt on flanks of main shield

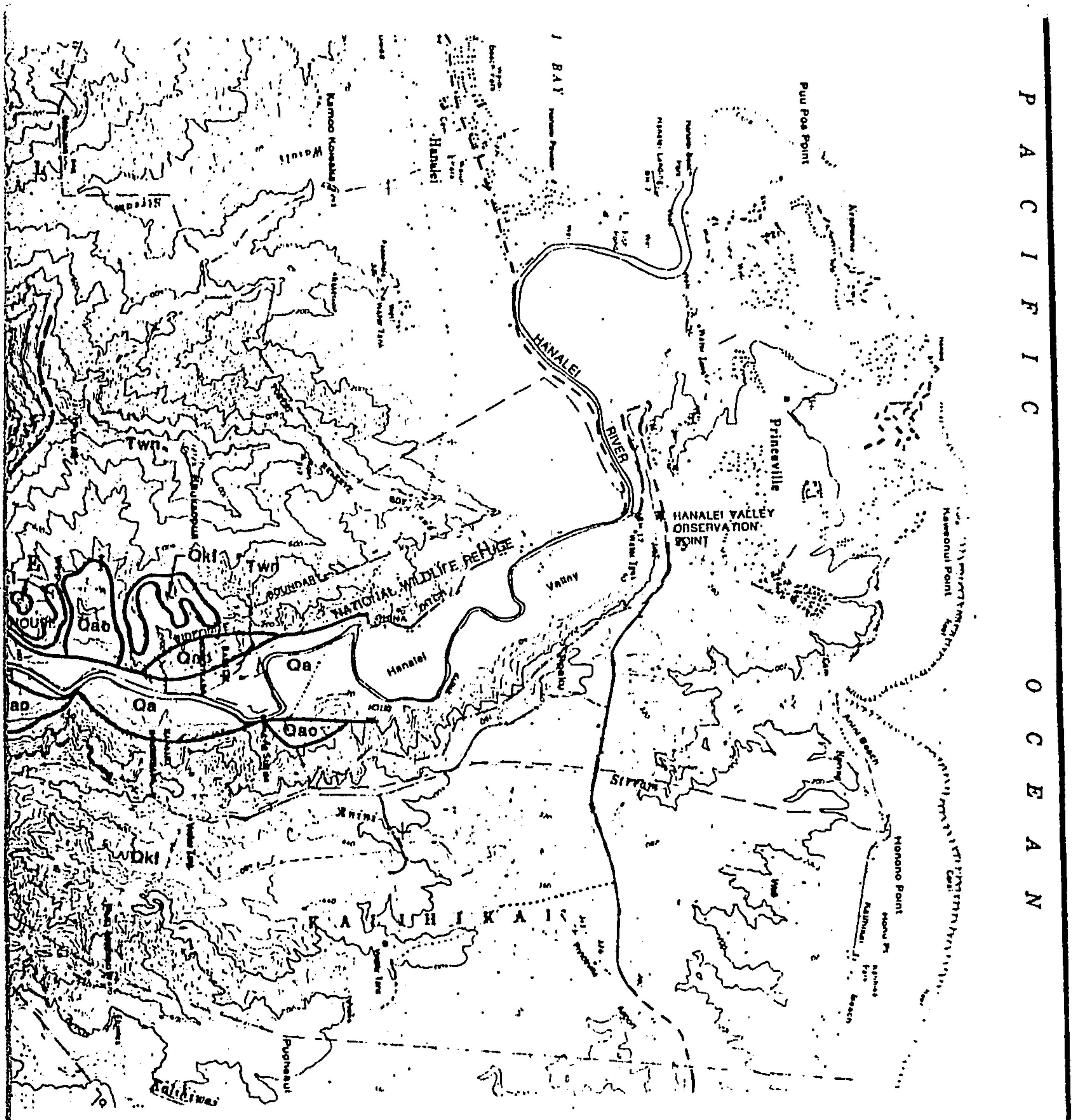
Two — Tertiary Waimea Canyon Volcanics, Olokele Formation Thick olivine basalt flows accumulated within the Caldera

Approximate boundary of buried, eroded fault scarp (ball on downthrown side).

Dikes intruded into Koloa and Waimea rocks.

NOTE:

Geology adapted from Gening Groundwater Resources of th Kauai, Hawaii, Bulletin 13, S Hawaii, Division of Hydrogra MacDonald et.al. 1960 Modif field mapping.



Approximate boundary of buried, eroded fault scarp (ball on downthrown side).

Dikes intruded into Koloa and Waimea rocks.

NOTE:

Geology adapted from Geology and Groundwater Resources of the Island of Kauai, Hawaii, Bulletin 13, State of Hawaii, Division of Hydrography, MacDonald et.al. 1960 Modified based on field mapping.

1400' 700 0' 1400' 2800

HANALEI HYDROELECTRIC PROJECT

GEOLOGIC MAP

BINGHAM ENGINEERING

Date JAN 1987 | Project # 609-014 | FIGURE 1

Hawaii and Maui. Again the affect on Kauai was not determined in detail but the earthquake was felt in Honolulu.

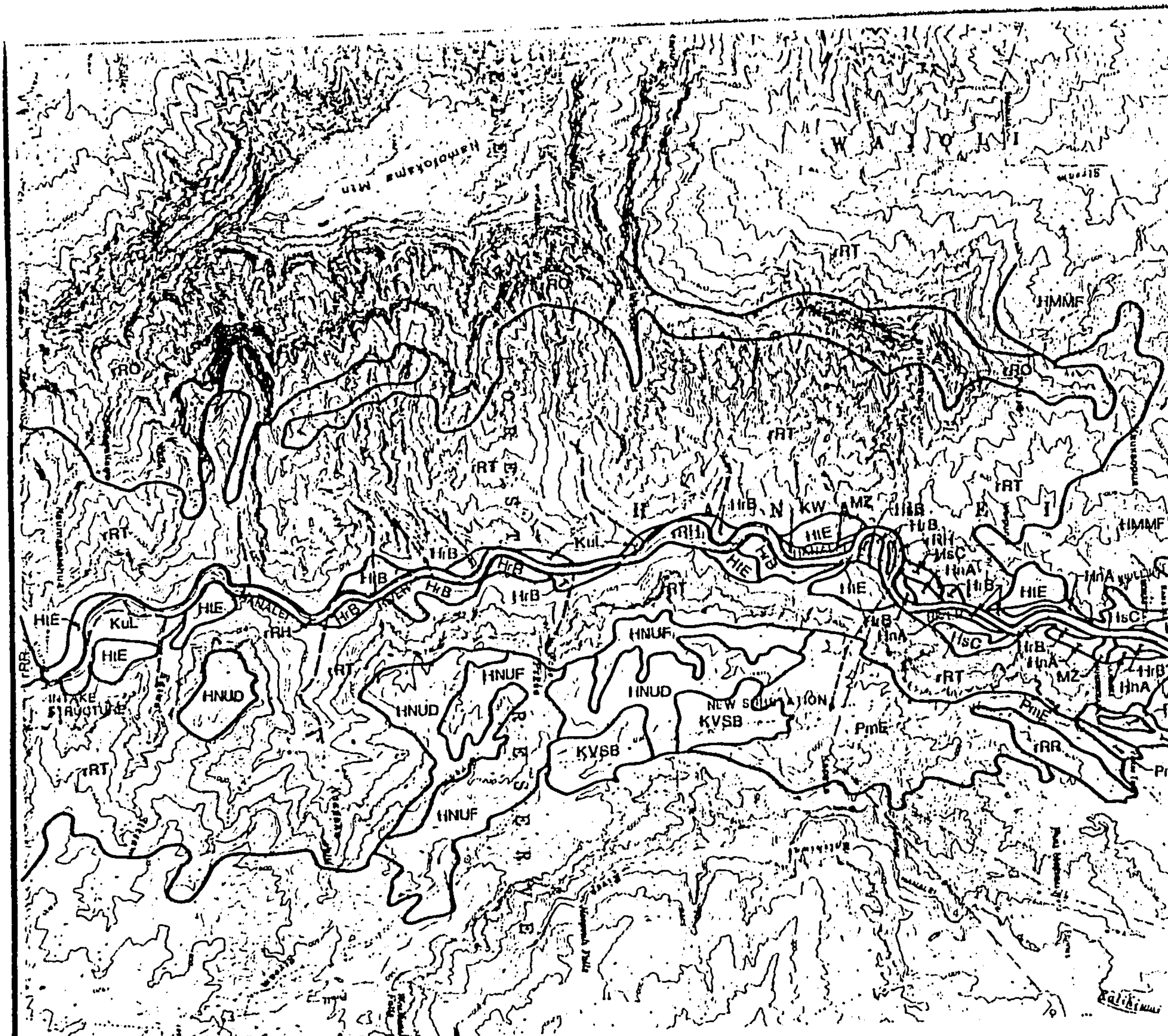
In considering the overall tectonic setting of the Hawaiian Archepelago all proper seismic considerations will be used in the design of this project. The Uniform Building Code assigns a seismic risk value of 0 to Kauai for design use. For proper evaluation the worst case should be used and it would be prudent to at least evaluate the final design in accordance with the requirements of Zone 1.

Soils

As described in the geology section the long period of quiessence after the build up of the main Kauai shield (Waimea Canyon Volcanics) allowed for the development of areas of deep soils. These were in part disturbed by the renewed activity of the Koloa volcanics but there exist areas of rich, well developed soils. The extreme slopes on the island and the numerous drainages have created deep alluvial deposits from which many of the soils have developed. Some have originated in coral and basalt sands and dunes but primarily they are alluvial soils or saprolitic soils weathering in-place from the igneous rock. The type or taxonomic classification of the various soils is based on the depth of development and the degree of slope. The narrow canyons play a critical role in some drainages by confining the soils between the prominent basaltic ridges.

The Soil Conservation Service classifies ten major soil associations on the island of which only two are found along the Hanalei River. These two are the Hanalei-Kolokolo-Pakala association. This unit is a deep, full range (level to steep), poorly to well drained soil with a fine to medium textured subsoil. The other association is the most prominent on the island and is really not a soil. The USSCS classification of this is the Rough Mountainous Land-Broken Textured Land-Rock Outcrop Association. It consits of well to excessively well drained very steep precipitous land (mountains and gulches) with extensive areas of exposed igneous rock.

The accompanying Figure 2 and Table 1 show the placement of these associations and the more detailed breakdown of the individually mapped units. The data presented on Table 1 describes the associated engineering characteristics of these soils units, the description is from the SCS, Soil Survey of Hawaii and the depths presented are typical. Within the planned construction corridor the depths are expected to average much less except near the powerhouse site. Measured soil thickness at several random locations is on the order of 1 - 2 feet except within the active channels of the Hanalei River and its tributaries. The Detailed Land Classification - Island of Kauai, from the Hawaii Land Study Bureau Bulletin No. 9 was consulted in evaluating site soils. No specific data from it is presented because it deals primarily with agricultural products of economic significance. Agriculture is not a primary concern in the majority of the project area and detail from LSB Bulletin 9 is not warranted. This is particularly valid considering the limited detail presented by the SCS for the same soils.



SOILS ALONG ALIGNMENT CORRIDOR

KuL (MH)	Kolokolo ext. Stony Clay Loam
HnA (MH)	Hanalei Silty Clay 0 - 2% Slopes
HrB (MH)	Hanalei Silty Clay 0 - 6% Slopes
HmB (MH)	Hanamaulu Silty Clay 3 - 8% Slopes
HmC (MH)	Hanamaulu Silty Clay 8 - 15% Slopes
HlE (MH)	Hanamaulu Stony Clay Loam
MZ (MH-CH,PT)	Marsh
rRH (SM-GP)	River wash and active alluvial soils

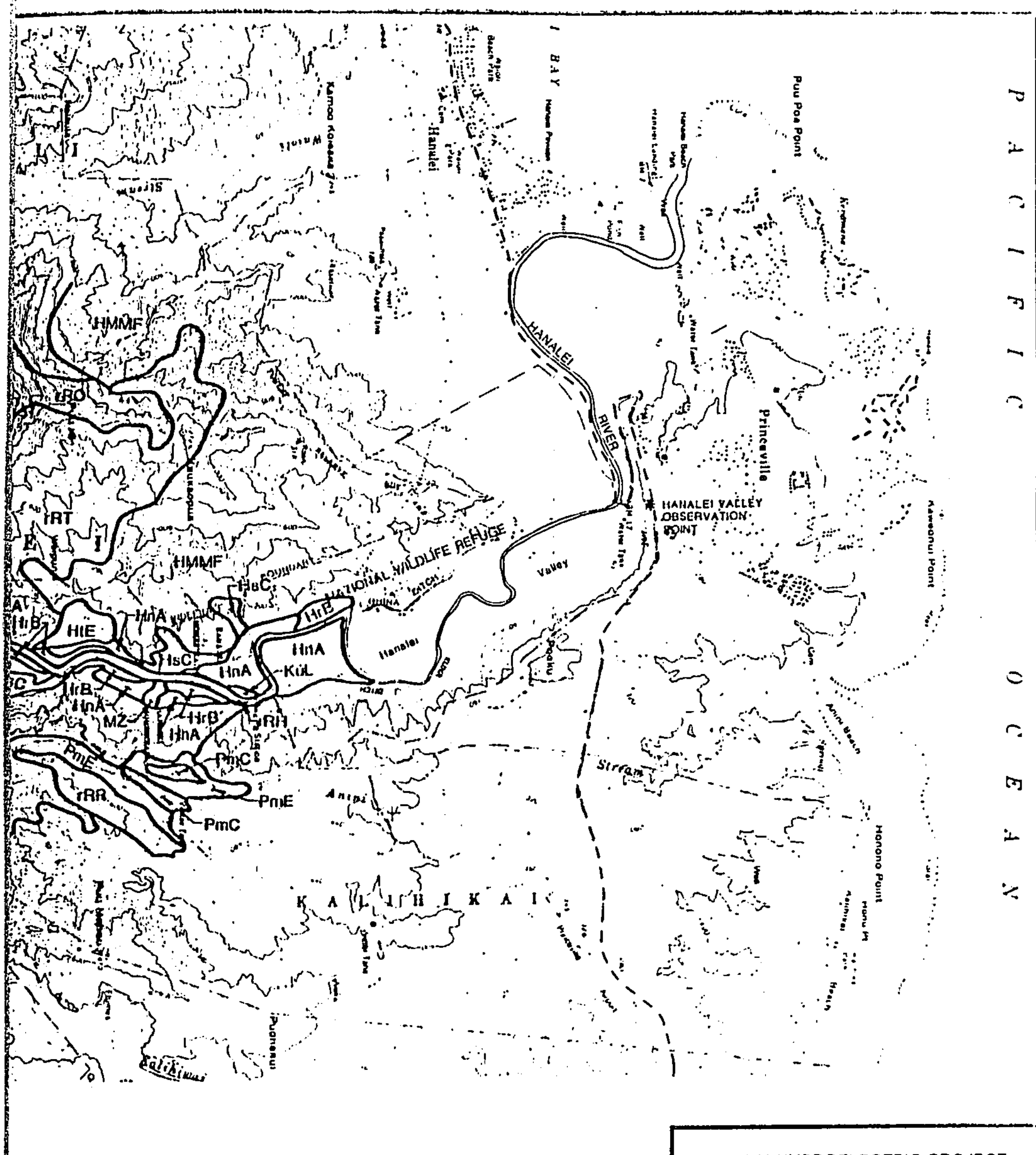
NOTES:

1. Classification in parenthesis (MH) is unified soil classification used for engineering property

   MH - inorganic silts, fine sands or silts
   CH - inorganic clays, high plasticity
   SM - silty sands, sand silt mixtures
   GP - poorly graded gravels, gravel sand mixtures
   PT - peat, muck or other highly organic soils

2. Soil classification from USCS Soil Survey of Islands of Kauai, Oahu, Maui, Molokai and Lanai (1972)

3. Classification described only for soils within project corridor other symbols provided for reference only



HANALEI HYDROELECTRIC PROJECT

USSCS SOILS
CLASSIFICATION MAP

BINGHAM ENGINEERING

JAN 1987

609-014

FIGURE 2

TABLE 1

SCS SOIL CLASSIFICATION AND ENGINEERING CHARACTERISTICS

OF SOILS IN THE PROJECT VICINITY

GROUP Hanalei-Kolokolo-Pakala

Unit	Depth to Bedrock (ft)	USCS	Permeability (in/hr)	Corrosivity Coated	Corrosivity Uncoated
Hanalei	>5	MH	0.63-2.0	High	Moderate
Kolokolo	>5	MH	0.63-2.0	High	Low
Pakala	>5	CL-ML	0.63-2.0	Low	Moderate

GROUP Rough Mountaineous Land-Broken Textured Land-Rock Outcrop

This unit is not classified into various categories because it is not used for agriculture. It is typically classified as natural habitat for wildlife and water supply. The soil unit is characterised by steep "V" shaped canyons.

Note: Depth criteria is based on average map unit areas. Site specific measurements indicate average depths of 2-3 feet.

ENGINEERING CONSIDERATIONS AND MITIGATION PLANS

Bedrock

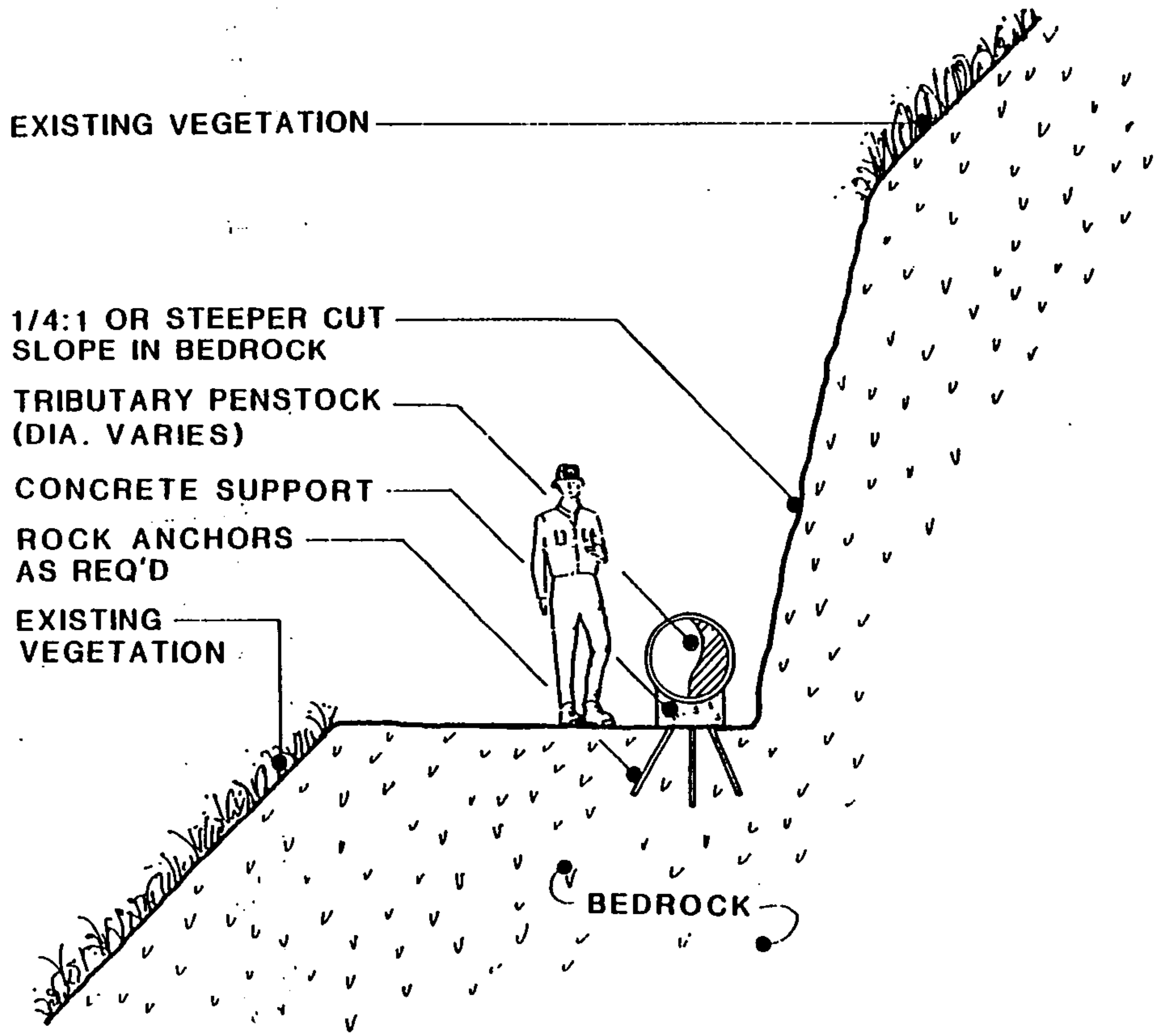
As discussed in the general description the rock at the site is primarily basalt with different degrees of fracturing. There are sections where the competency is not a concern and any foundation type would be adequate as long as it is anchored in the rock in some fashion. There are some factors which must be considered when evaluating anchoring systems. In the rock sections that are fractured there must be assurance that the attachment is firm. Pre-boring and placement of rock anchors or rock bolts will be required in many of these sections (Figures 3 and 4). The boring and anchor should be into competent rock not within a fracture. Where necessary a surface layer of concrete may be placed to create a smooth base for the anticipated structure. In this case the boring locations should be located in advance so that fractures will not be encountered below the concrete. The rock anchoring system described will be used where required to tie the concrete cradles or pedestals to the foundation to provide support for the pipe at the required intervals.

There should be no major difficulties with the rock other than excavation and removal where required. If possible, larger sections of rock should be removed by controlled low energy blasting or hydraulic splitting. The control and grades should be carefully selected to eliminate as much excess waste rock as possible. Control of waste rock will be important so that excess material will not enter the stream. When rock removal is required there will be adequate measures taken to eliminate rock fall or debris from the site. Much of the rock will be of a dimension that is usable and only that which cannot be used in construction or placed around the vicinity for landscaping will have to be removed.

In the areas where temporary diversion of the river is required for construction there are several alternatives which depend on the type and competency of the rock. Small tunnels or open channels to bypass water by the construction site will be effective where the channel shape allows. These tunnels or channels will serve as semi-permant facilities which would even be re-usable to facilitate repairs or alterations later.

Soils

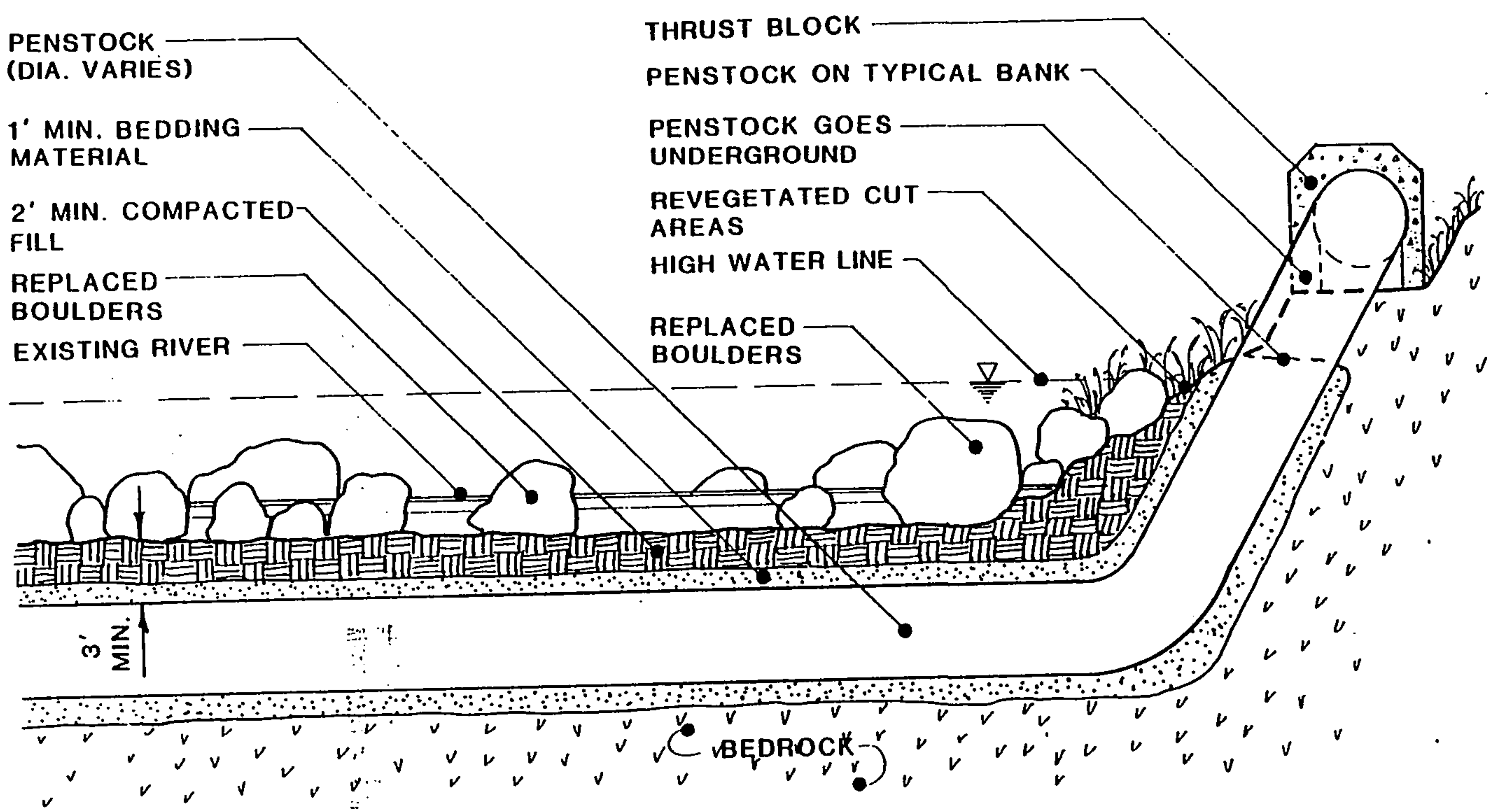
Handling of soils from the site during the construction process will require adequate planning and control to eliminate discharge of excess sediment into the Hanalei River. In order to control any discharge that may occur sediment traps will be constructed near areas where introduction is likely. This can be accomplished by either excavating deeper channels into the river banks or constructing temporary catchment systems. The small coffer dams can be constructed from either natural materials or synthetic "geofabrics or geomembranes". The advantage of these is that they can be removed easily and the landscape can be reworked to natural conditions.



SECTION OF PENSTOCK ON STEEP BANK

SCALE: 1/4" - 1'-0"

FIGURE 3



SECTION OF PENSTOCK AT RIVER CROSSING

SCALE: 1/8" - 1'-0"

FIGURE 4

During the river crossings it is anticipated that the soil in the channel will be slightly deeper than along the side channels. This condition was confirmed during the field investigation, particularly downstream near the powerhouse where the channel profile becomes deeper and more developed. Sediment control in the upper reaches will be more basic because of this. Downstream there will be deeper sections to control but more room.

During the construction of the segments in the stream a temporary diversion just upstream will be required to route the active channel around the construction site. This will allow for the control of sediment in the construction area and provide more favorable working conditions. These small diversions may be constructed of on-site soils, geomembranes or a combination of both. They will be of sufficient depth to allow settlement of the majority of the suspended soils and will have a small overflow structure to allow the clear water to re-enter the active channel. Where the penstock actually crosses the active channel it will be buried and backfilled with suitable compacted material. Enough coarse gravel and boulders will be placed over that section to prevent undermining and movement of the pipe by flows within the river channel (Figure 5).

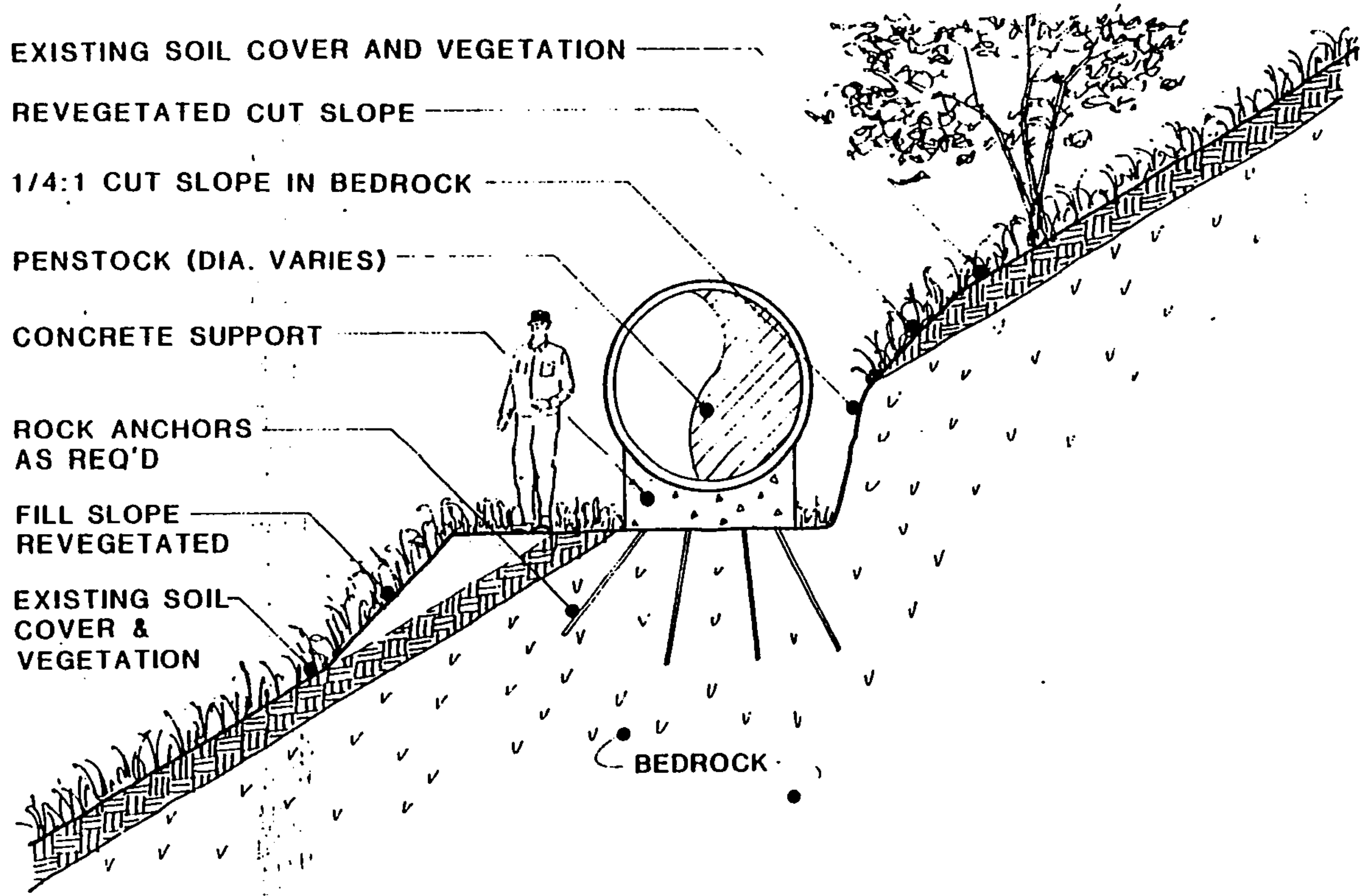
Seepage

Seepage from the diversion structure is not expected to be a problem. Basalt flows mapped at the site do have a moderate to high degree of fracturing and some seepage is anticipated. Foundation preparation and construction will be planned to control seepage however the majority of flows not diverted in the structure would likely flow into the basalt and re-enter the channel downstream. The very low volume of storage within the small diversion structure also greatly reduces the problems associated with seepage. Careful compaction of site soils where removal is not practical will also be required to help control seepage. It is anticipated that all critical aspects of the foundation will be on bedrock. This is planned to eliminate or greatly reduce the need for grouting.

None of the small dikes identified in the field would create any difficulties with the project due to their orientation. If larger more massive dikes are encountered near the diversion, which run perpendicular to the channel, their potential for intercepting flows in the shallow subsurface will have to be investigated. Such dikes may act as confining "basins" and would tend to reduce seepage. Site investigations at the diversion site indicate that there are no apparent difficulities regarding seepage or groundwater conditions. A more detailed field investigation will be carried out prior to construction and any geologic concerns can be further addressed at that time.

Slopes

Most of the slopes measured in the field were 1:1 or steeper. There are numerous sections where smaller talus slopes have developed composed of material weathering from the steeper slopes. Slightly flatter sideslopes are also located along the channel, primarily the east side, which are



SECTION OF PENSTOCK ON TYPICAL BANK

SCALE: 1/4" - 1'-0"

FIGURE 5

composed of more fractured basalt and some interbedded gravelly sections. It is these flatter, less consolidated slopes that may present problems with stability. The loose material may become unstable when lateral support is removed during construction. Several alternatives are available for mitigating this problem. The easiest method would be to establish berm type counter-balance structures from the plentiful river gravels and boulders located along the alignment. Some of the worst case conditions may require temporary retaining structures of compacted earth. There are no conditions anticipated which could not be controlled through standard construction methods.

Plans have included a monitoring and repair schedule for occasional slumps or slides in the unconsolidated material for the period after construction and before vegetative support is established. If unconsolidated slopes are properly compacted and left at or near 1:1 there should be no major concerns, particularly if boulders are used for toe support and erosion control.

Where rock cut is required it will be accomplished through the controlled blasting or hydraulic splitting methods outlined above. Rock cuts less than 50' high could be set to 1/4:1 or steeper. Higher rock wall cuts could be cut to this slope and terraced with 8-10' flat terraces then another 1/4:1 rock cut. Terracing could be eliminated by 1/2:1 or 3/4:1 cuts in the rock.

SITE INVESTIGATION

The site investigation of the project area included both helicopter reconnaissance and a two day field survey of the intended alignment. The field survey followed the river from above the diversion to the powerhouse site.

From a purely geologic sense the alignment is all basalt of the two described flows. The key concerns in the evaluation are the engineering geologic factors in how the rock units will behave and the environmental factors such as potential hazards and other geotechnical issues. More detail is presented in the specific geotechnical section of this report but basicaly it can be stated that the alignment is satisfactory from a hazard point of view, is located on the flatter terrain near the river, and the principle concern is for placement of the penstock on the shallow bedrock near the active stream. The diversion site is on a point of very near surface or exposed basalt. Consequently the foundation competancy in the area of the diversion is not a concern. The construction method will be more involved, however, because of the amount of rock excavation and anchoring method.

Several dikes were mapped during the field survey. They were plotted to determine if they were oriented in a fashion that may affect the water carrying capacity of the stream or near surface fractures of the rock units. Most of the dike swarms run essentially parallel to the channel and although they appear much less permeable than the country rock they should have no adverse affect on the water flow by creating a daming effect.

The different flows in the vicinity of the alignment are readily identifiable based on varying degrees of jointing and vesicularity. The more massive sections near the alignment appear competent and should not pose any problems to the construction of the project other than difficult excavation. All areas surveyed have either exposed bedrock at the surface or evidence of very near surface rock. In the active channel area and flood plain the soil deposits are typically quite thin and do not become well developed until the break in slope where the prominence of more woody vegetation is clear. Many areas long the side channels did have poorly developed soils but the vegetation was well developed penetrating into deeper fractures and joints in the rock. The side slope channels are very steep and the break in slope at the flood plain is quite prominent. The average flow level of the river and the periodic high flood levels are easily identified in many places by rock patterns, water lines and suspended flood debris. Near the lower reaches of the river the change in gradient is readily identified with associated wider flood plains and thicker soil sections. Some of these soils sections are obviously quite deep. The widening of the channel and the development of low energy geomorphic expression indicate a deeper more fine grained matrix of silty or clayey soil with high organic content. The density of vegetation also indicates this. To date no on-site excavations or borings have been placed but it appears that the powerhouse site is in an area of deeper alluvial soils with basaltic gravels and a very high water table.

Field Notes (March 1, 1986)

Rocks in the vicinity of the river from the helicopter drop to the diversion are basalts of various types and sizes. Some are quite massive and in-place while some are obviously alluvial which have been transported downstream and are well rounded. They are open vesicular rocks not from the local flow. The local in-place rock does not display obvious vesicularity. Some boulders are massive 3-8 m wide, 2-4 m high which appear to be a conglomerate (agglomerate) with evidence of flow banding in some sections. The rock is very dense. Permeability would be primarily through the jointing. There is no strong evidence of dikes here although vegetation is quite heavy. Prominent jointing is evident all along the section which is primarily vertical to about 5 degrees off of vertical which would be inducive to dike emplacement. Jointing trends north. The smaller alluvial gravels are probably from the Waimea Series to the west below Mt. Waialeale. Evidence of structural control is prominent as suggested in the literature as being due to later flows from the east forcing the river against the Waimea Series. The west wall is prominent and near veritical and is more massive than the east side rocks. Side channel rocks would work well with rock bolts although there is some massive jointing which may not have shallow closure and rock bolts would have to accommodate these joints. There are many thick 1 m + sections.

Upstream of the diversion there is a section of dike rock which strikes N20E, is variable and undulatory, with sequencial fracturing (cooling induced). It ranges from 12 to 30 mm thick but is quite variable.

The first sample collected is the dike rock. Permeability may cause seepage concerns if the orientation of the joints are perpendicular to the channel. The present strike would not cause problems and appears to be the common orientation. Lava flows are primarily massive with some pahoehoe and thin lensing.

Side channel slopes are very steep and are estimated to be 55-65 degrees (Brunton) using the tree line.

Average slope measurements are very steep in massive basalts. Channels are very narrow. I would anticipate 100% bedrock placement of structures. Rocks at the diversion are massive flows in a very narrow channel. Significant undercutting is occuring at the bottom of most plunge pools. Bedrock displays prominent parallel jointing. Most likely good to excellent foundation conditions exist. There is one dike parallel to the channel at the diversion. I see no problems other than material transport and excavation in the rock, the jointing and the steep sidechannel. Joints strike E-W at 70 degrees from horizontal. The bedrock is blocky and massive with some 12-15 m thick blocks that have fallen out of the exposure within the channel.

Foundation conditions for the penstock are generally good however it is apparent that there will be a majority of bedrock excavation with significant amounts of shooting and transitions to allow for the channel configuration. The foundation conditions at the powerhouse site are obviously much lower in the section and are at a flatter grade and therefore have deeper alluvial sections composed of fine grained soils. The channel is wider and deeper at this point and there will need to be some shallow borings in the powerhouse vicinity to complete the total design for the structure. It would be wise to obtain accurate depth to bedrock data and blow count information in the channel soils in case they are too deep to accommodate a bedrock foundation.

B-6d ECONOMIC INVESTIGATIONS

INTRODUCTION

A potential hydropower project must satisfy two basic criteria to be economically feasible. First, the economic value of the output must be greater than the cost of production. Second, its output must be marketable at rates sufficient to recover costs. Economic feasibility is measured with benefit/cost analysis. The benefit is the utility companies' measured willingness to pay for energy produced by the hydroelectric powerplant. The cost of the energy displaced by the production of hydroelectric output is taken as a benefit. Appropriate sizing of the most economically efficient hydropower plant was performed. The current maximum capacity of 8,000 kw with an average annual output of 29.5 million kilowatt hours was selected for this study.

ECONOMIC CONDITIONS

POPULATION

There are two main sources of projected population growth for Kauai. They are the State of Hawaii Department of Planning and Economic Development ("DPED"), and OBERS 1980 projections by the Bureau of Economics Analysis ("BEA"), US Department of Commerce. The OBERS BEA projections for the non-SMSA portion of Hawaii, which includes Kauai, shows a growth rate somewhat lower than the latest figures resulting from DPED projections. The validity of the OBERS projections follows from the soundness of the control total approach, in which reliable national projections are first made, from which smaller regional projections are derived by disaggregation. The validity of the DPED projections, however, follows from County growth rate forecasts based on historical trends. The two projections are shown in Table B-6d-1, and depicted graphically in Figure B 6d-4 ..

TABLE B-6d-1

HISTORICAL AND PROJECTED POPULATION GROWTH
FOR KAUAI

POPULATION (1,000's)

		PROJECTED		
		OBERS 1/		
	Historical	Low	High	DPED 2/
1950	30.7			
1960	27.8			
1970	30.1			
1980	39.1			36.5
1985		42	43	40.6
1990		45	47	46.5
1995		48	51	53.1
2000		51	55	60.4
2010		55	60	
2020		58	65	
2030		63	70	

1/ Based on growth rate for non-SMSA portions of Hawaii, 1980 OBERS BEA Regional Projections, US Department of Commerce, Bureau of Economic Analysis, July 1981.

2/ State of Hawaii, Series II-F Projections, March 1978.

The DPED projections are under revision at this time in response to 1980 census figures. Kauai's census, for example, is 39,082, or 6.6% higher than had been projected for 1980. All three scenarios show continuing growth, although at different rates.

POWER VALUES

Power Values on Kauai are directly related to the price of oil. Although oil prices have sharply declined in recent times, a gradual increase in pricing has already begun. These prices are expected to increase at a steady pace in future years.

Feasibility is based upon the price Kauai Electric is willing to pay for the project power. This price is measured against the cost of the power produced by the project.

The expected cost of power production of the proposed Hanalei Project is between 7.0¢ and 7.5¢ per kilowatt hour. As operation and maintenance costs will increase each year, this cost will escalate at about 1.5% per year during the first 20 years. The costs during this period include service for the financing used to construct the project. Beginning in the 21st year, the financing will be paid off and the cost per kilowatt hour will drop to about 6.5¢. This cost is also expected to escalate at about 1.5% per year.

Negotiations with Kauai Electric indicate that the utility will purchase the project power output for the expected cost of production for a term of 35 years.

SUMMARY AND CONCLUSIONS

Based on the power value data and a total project cost of $13,984,194 the hydropower project is economically feasible.

ENERGY USE

Barring drastic changes in the economy and lifestyle, all three population growth scenarios represent a continuing requirement for electricity production. Population is of course only one of the variables linked to electricity generation and use. While population growth averaged about 2.6% per year during the 1970's, electricity generated increased by an average of about 4.2% per year, as shown in Table B-6d-2. In addition to residential use, for which population is the primary indicator, commercial, industrial, and public use all have contributed to this growth. Future growth will be tied to developments in the economy in general, specifically in the agriculture and tourism sectors, and by extension the construction industry. The behavior of the world petroleum market will also be a significant factor along with related trends and developments in alternate forms of energy use and production, conservation, and changes in lifestyle. Table B-6d-3 shows electricity demand forecasts by County to the year 2005. The forecast shows growth rates of around 4% annually through 1990, decreasing to about 3.6% per year by the end of the forecast period.

TABLE B-6d-2

ANNUAL ELECTRICITY GENERATION, KAUAI[1/]

Year	Net Electricity Generated (millions of kwh)	Annual % Change From Previous Year	Annual % Change From 1975
1975	161.2		
1976	167.6	3.8	3.8
1977	183.2	8.5	6.2
1978	201.0	8.9	7.1
1979	204.2	1.6	5.7
1980	211.1	3.3	5.2
1981	218.7	3.4	4.9
1982	217.0	0.8	4.1
1983	224.8	3.5	4.0
1984	247.1	9.0	4.6
1985	248.8	0.7	4.2

1/ From Communication, Citizens Utilities Company - Kauai Electric Division, July 28, 1986.

TABLE B-6d-3

KAUAI COUNTY ELECTRICITY DEMAND FORECAST, 1978-2005
(Million KWH)

Kauai Electric Projection1/

Year	Energy Sales	Average Annual Percent Change
1978	*201.0	
1982	*217.0	2.0
1985	*248.8	3.1
1990	319.9	4.0
1995	387.4	4.0
2000	454.8	3.8
2005	522.2	3.6

1/ From Communication, Citizens Utilities Company - Kauai Electric Division, July 28, 1986.

* Actual sales by Kauai Electric Division.

ALTERNATIVE ENERGY AND SELF SUFFICIENCY

Kauai is too remote for submarine transmission cable intertie systems. While a link via cable is the subject of a feasibility study for the islands of Oahu and Hawaii, Kauai's remoteness (102 miles from Honolulu, and 10,800 feet of water depth) makes any such intertie highly unlikely for the foreseeable future. In working toward the goal of energy self-sufficiency, other non-fossil fuel sources have been the subject of planning efforts. The most recent step in Kauai's drive for oil independence came with the start-up of the Lihue Plantation Company's bagasse-fueled powerplant.

E-1. KAUAI POPULATION GROWTH

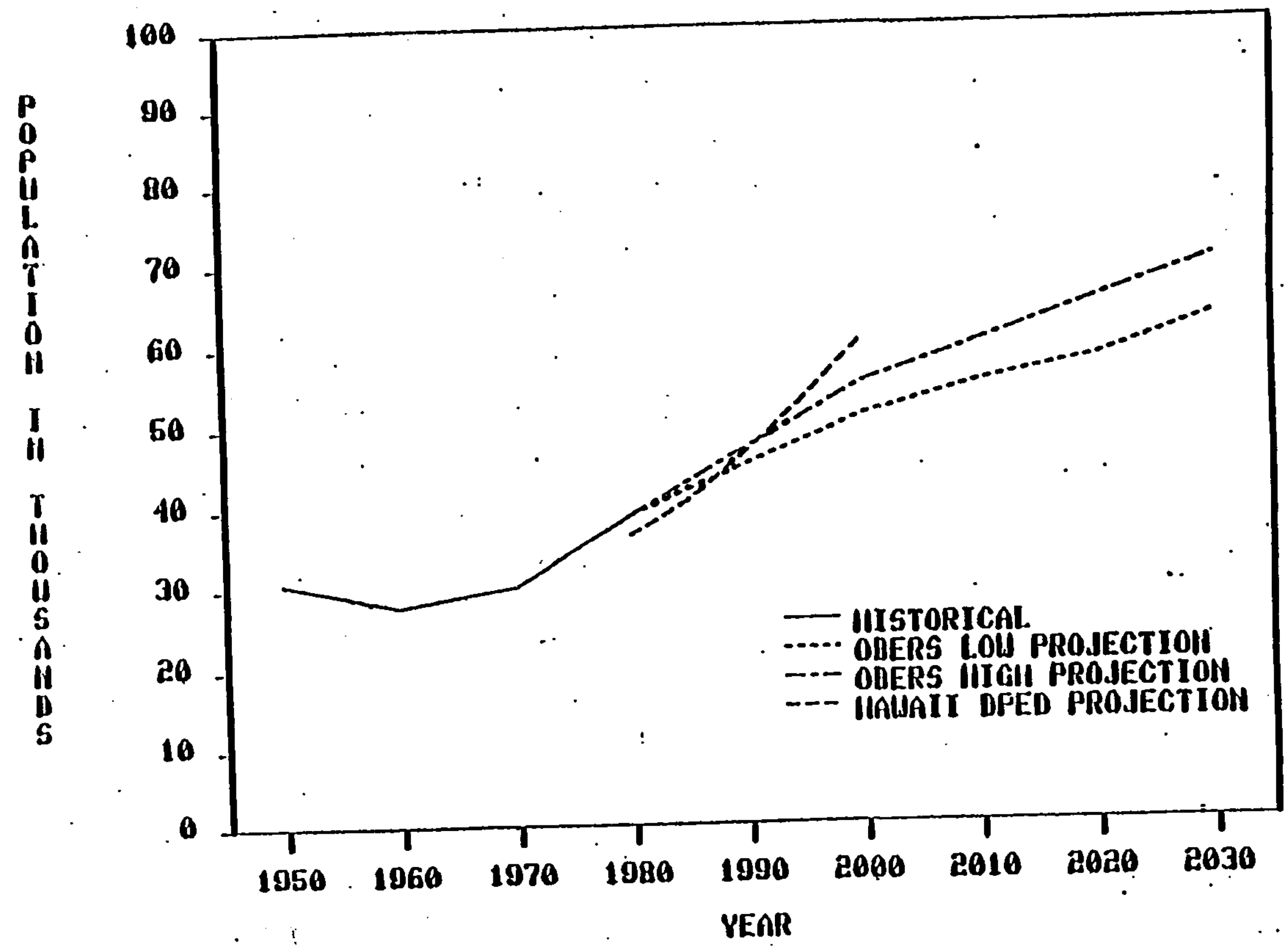


figure B-6d-4

B-7 HISTORIC PERSPECTIVE

Historic Perspective

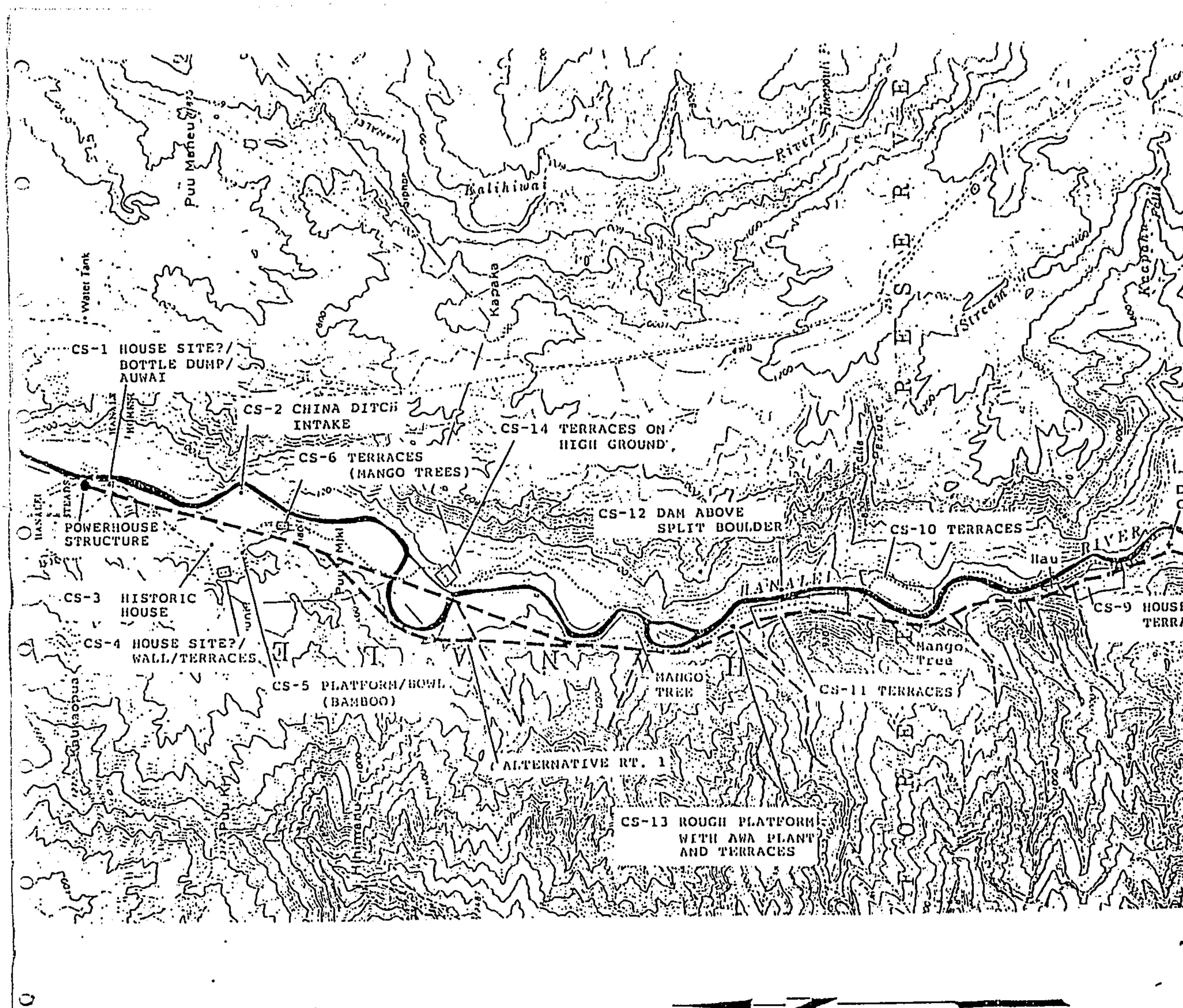
1. Identification of historic sites is required by the Reservoir Salvage Act of 1960 as amended, Section 110 of the National Historic Preservation Act of 1966, and Executive Order 11593 (1971). The Federal agency must evaluate the significance of the sites in order to determine possible eligibility for the National Register of Historic Places. If any sites in the project area are determined eligible for or already listed on the National Register, they would be protected by Federal law and regulation to the extent that the Federal agency must consult with the State Historic Preservation Office and the U.S. Advisory Council on Historic Preservation to determine the effect of the Federal project and to identify measures to either avoid or mitigate for any adverse affects.

2. The identification of historic sites within the study area is based on "Archaeological Reconnaissance of Upper Hanalei Valley Halele'a, Kauai", by Hallett H. Hammett, Ph.D. and Douglas Borthwick, B.A. Cultural Surveys Hawaii in October 1986 and W.C. Bennetts 1929 Survey of the Hanalei Valley.

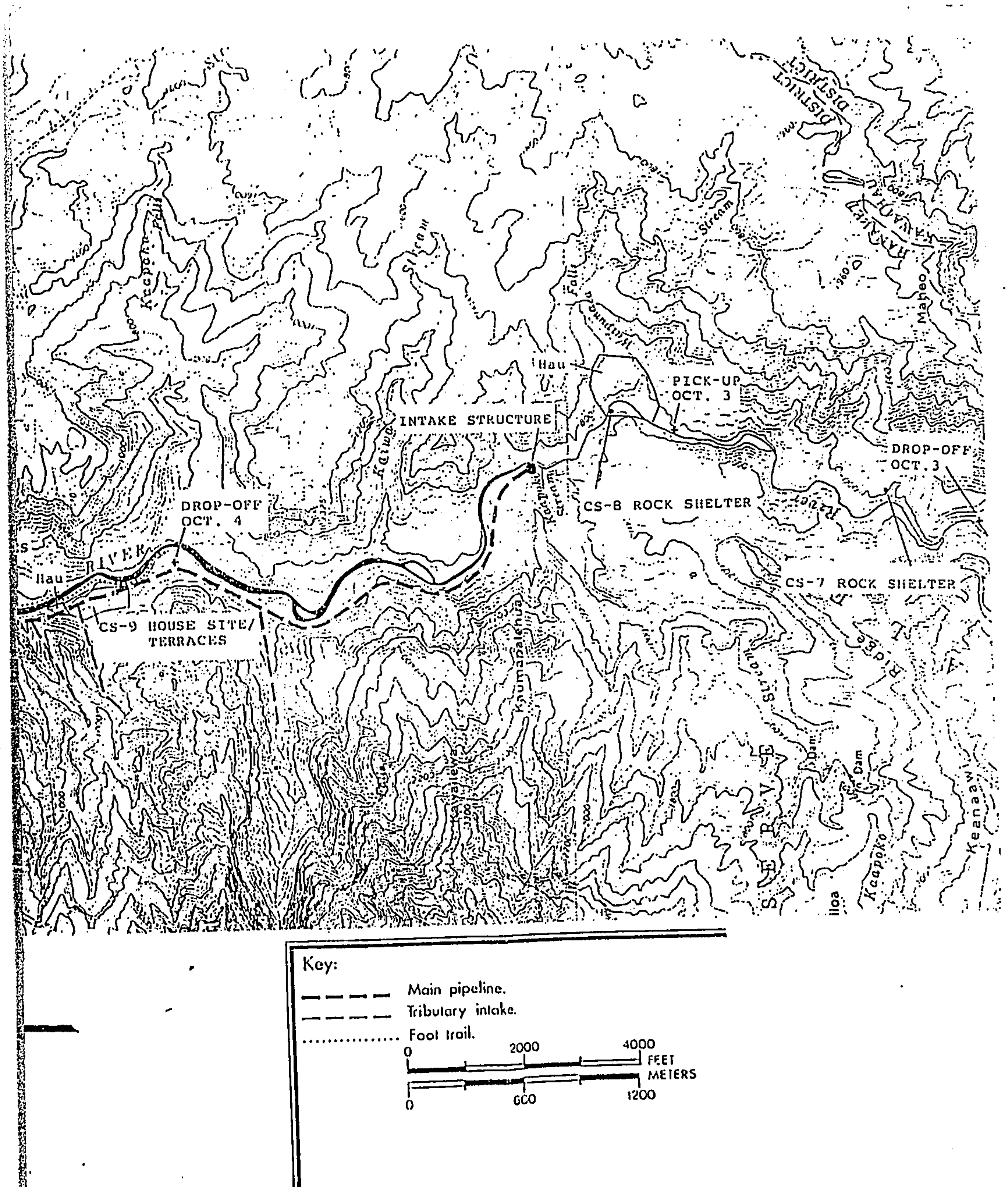
   This reconnaissance is the first formal archaeological investigation of upper Hanalei Valley since W.C. Bennett's 1929 survey. We are aware of the historical importance of this project and for this reason have attempted to record even minor details of the fieldwork. Our difficulty in interpreting Bennett's notes and site locations and making correlations of his sites to the sites we found underlines the importance of seemingly obvious details. To this end we have included improved field sketches of many of the the sites. No doubt Bennett had the same difficulty in locating himself in these wild regions as we did and did not have the advantage of a helicopter and a locally knowledgeable pilot. However, we are now confident in the locations shown ır • and consider the mapped trail and vegetation markers essential information for any future trips to the Valley. The results of this study are further discussed in Section C, Description of Environmental Setting, of this report. Dr. Hammetts study is included as Appendix IV to this report.

3. Figure B-7-1 shows the project area including the proposed pipeline routing and archeological site locations. A discussion of these sites is contained in Section C of this report.

4. No archaeological survey has been conducted along the proposed right-of-way for electric powerlines connecting the powerplants with the substation. The exact route of the powerlines have not been determined so that conducting premature archaeological surveys would not be cost effective. An archaeological reconnaissance survey will be performed following project authorization.



Project Area Showing Archaeological Site Locations and Proposed Pipeline Route.



DISTRICT
KAWAIHAU
Stream
Falls
Hau
PICK-UP
OCT. 3
INTAKE STRUCTURE
DROP-OFF
OCT. 3
DROP-OFF
OCT. 4
CS-8 ROCK SHELTER
RIVER
Hau
CS-7 ROCK SHELTER
CS-9 HOUSE SITE/
TERRACES
Ridge
Kaapoko
Keanaawi
Key:
Main pipeline.
Tributary intake.
Foot trail.
0
2000
4000
FEET
METERS
0
600
1200

figure B-7-1

Effects Evaluation

5. Rock shelters CS7 and CS8 are outside the project and would not be impacted. CS10, 12 and 14 are on the east side of the river and would only be impacted by possible secondary activities such as roads, staging areas, etc. Site CS3, 4 and 5 are to the west of the pipeline but the terraces of CS4 could extend to the river bank. The terraces of Site CS6 would also probably be impacted. Sites CS9, 11 and 13 site areas are *definitely* in the path of the proposed pipeline and would be directly impacted by the presently planned route of the pipe.

   Because of the constraints of this reconnaissance (mostly dense vegetation), the boundaries of these site areas are not well defined. There could be other as yet undiscovered sites on other point bars which were not examined. These sites in some cases could extend at least for a short distance up tributary streams where side intakes are planned.

   For these reasons, a more thorough survey is recommended for the exact route of the main pipeline as well as the tributary intakes. Taking into account our experiences in this reconnaissance, this survey should be undertaken after the pipeline corridor has been surveyed and at least partially cleared of vegetation.

   At the completion of this survey it should be possible to accurately define site boundaries in relation to the exact pipeline route to find other as yet undiscovered sites. There are 4 major point bars along the pipeline route not covered in this reconnaissance that may contain archaeological sites.

On the basis of such a survey, mitigative action can be recommended such as adjusting the pipeline route or further documentation of sites if impact is unavoidable.

The existing historic values are further discussed in Section C of this report and the probable impacts of potential historic sites are discussed in detail in Section E of this report.

C. DESCRIPTION OF ENVIRONMENTAL SETTING

THE STUDY AREA

The study area is located on the island of Kauai, Hawaiian Islands. Except for the Midway Islands in the northwest part of the Hawaiian Islands, the archipelago is under the jurisdiction of the State of Hawaii. The capital and major urban center in the State is Honolulu, island of Oahu. the Hawaiian Islands are geographically important, based on military and economic relationships to the Pacific Basin and to the Far East. The location of the islands relative to important centers is shown in Figure C-1.

The island of Kauai is the fourth largest island in the chain with an area of 553 square miles and the fourth largest island in population at 39,082 persons (Census, April 1980) (1985 estimated population - 44,800). The County seat is located at Lihue. The major population centers are located at Kapaa (4,467 persons), Lihue (4,000), Kakaha (3,250), and Hanamaulu (3,227). The location of the Hanalei River basin on Kauai is shown in Figure C-2.

Hanalei Valley is located on Kauai's north shore. It is long, relatively narrow, and extends from the sea to Mount Waialeale. For the first 8 miles the valley floor ascends to an elevation of only 180 m. In the remaining 3 miles the valley floor rises to 1,500 m. Its width varies from 1 to 3 miles. The drainage area is 19.1 square miles.

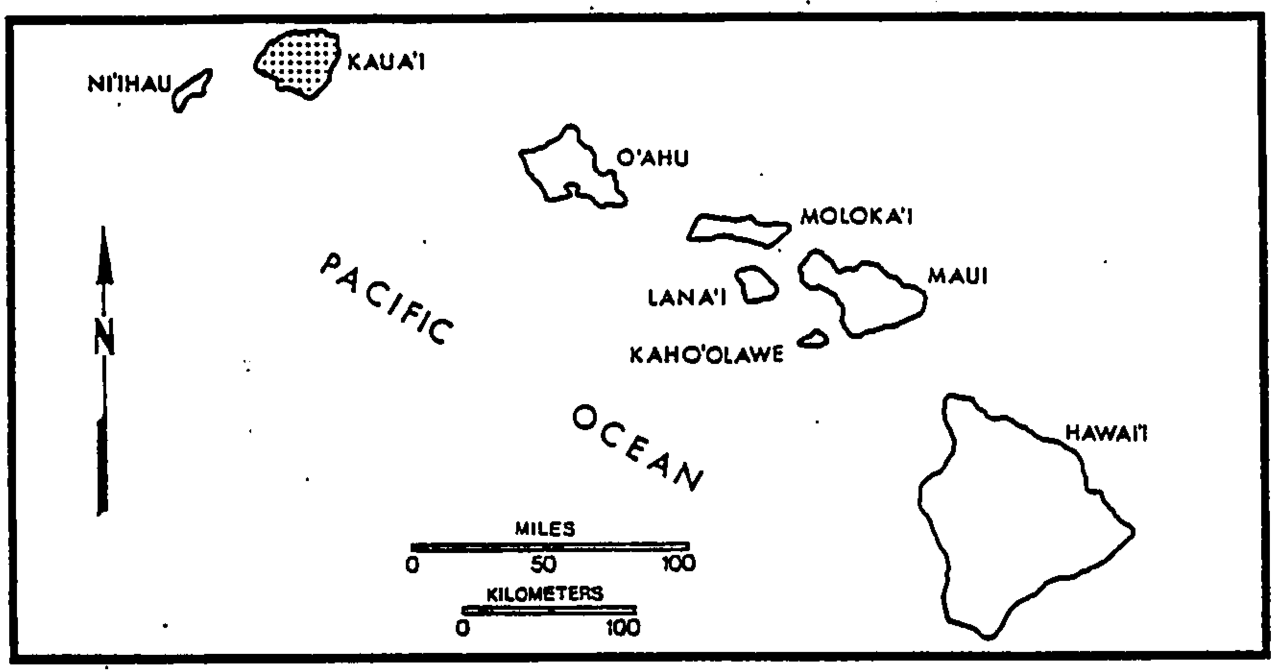


FIGURE C-1
State of Hawai'i

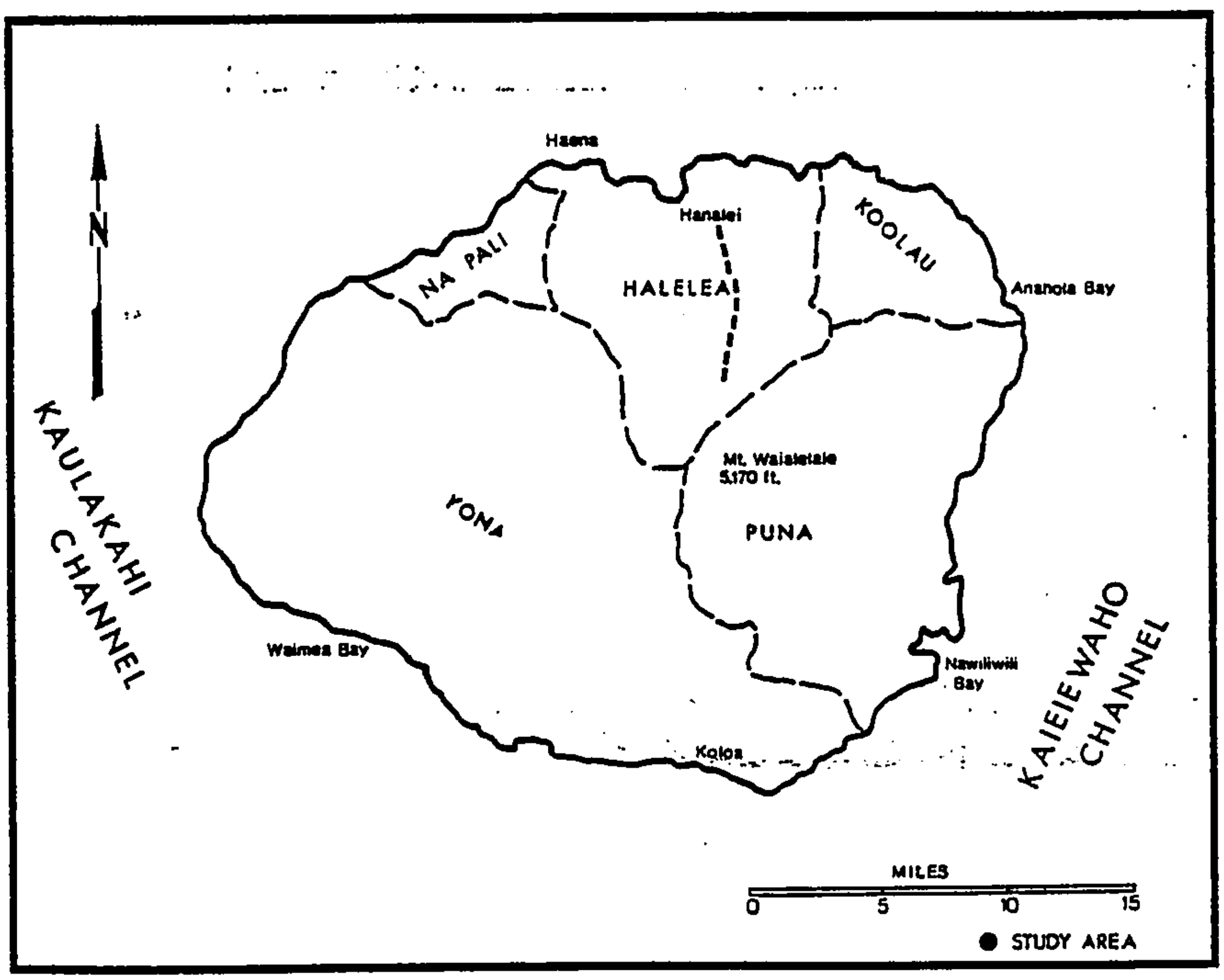
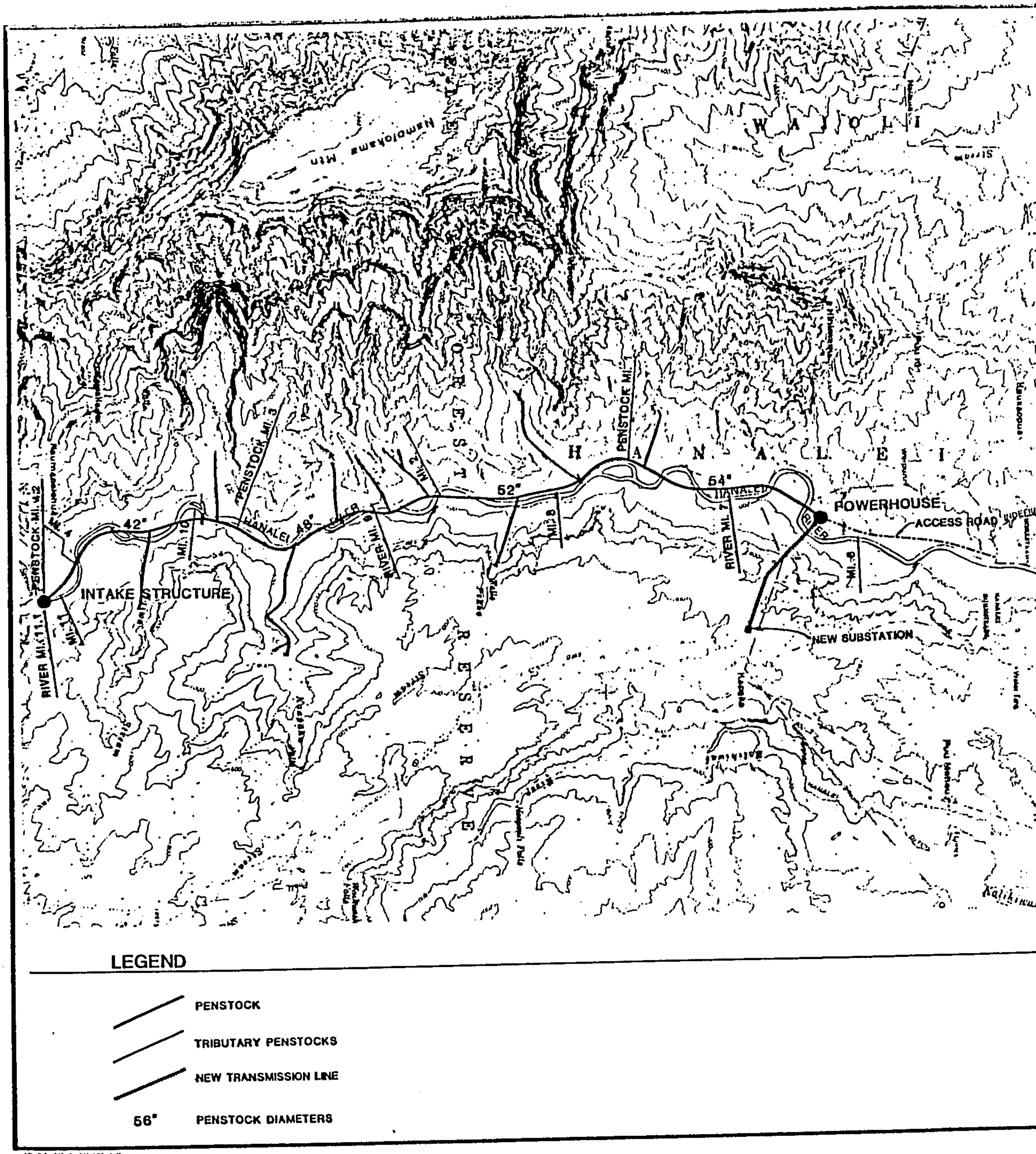


FIGURE C-2
General Location Map, Kaua'i Island

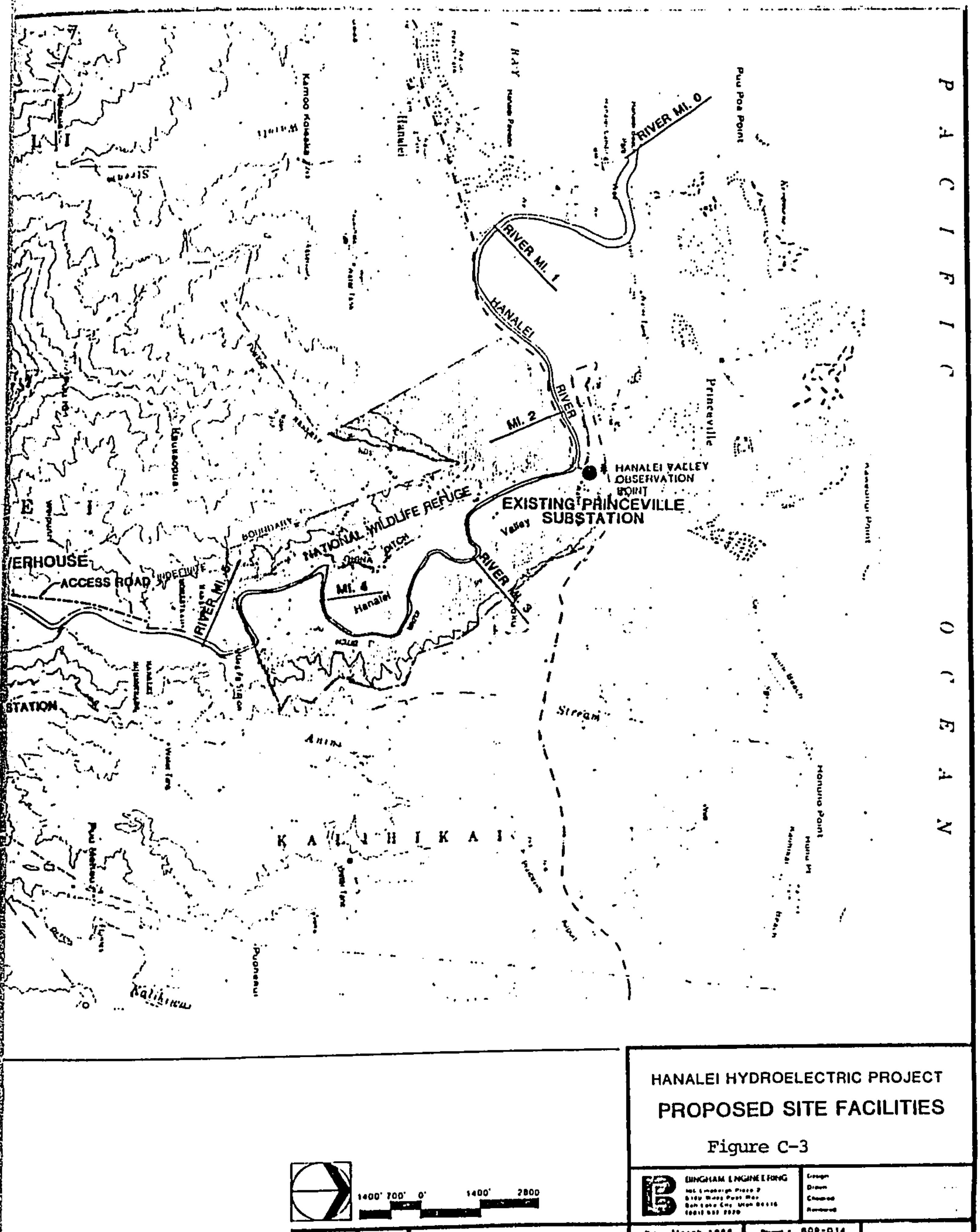
Annual rainfall varies from about 100 inches near the coastline to about 450 inches at the head of the valley. The average monthly air remperature in 68° to 70°. The average wind velocity is about 7 m/h and blows predominantly from the east (Ramage and Oshiro 1977).

<u>Hanalei River and Location of Proposed Facility</u>

The proposed hydropower facility is shown in Figure C-3. The location of the diversion weir, penstock, and power plant in relation to the stream channel and drainage basin are shown in this figure. Surface flow will be diverted at 650 feet elevation, conveyed through a penstock (pipe) for about 5 miles and released downstream as tailwater after passing through turbines in the powerhouse located at about 85 feet elevation.



WAIOLI
HANALEI
FOREST
RESERVE
INTAKE STRUCTURE
POWERHOUSE
ACCESS ROAD
NEW SUBSTATION
PENSTOCK MI. 12
PENSTOCK MI. 3
PENSTOCK MI.
RIVER MI. 11.1
RIVER MI. 9
RIVER MI. 7
HANALEI RIVER
42"
48"
52"
54"
MI. 11
MI. 10
MI. 2
MI. 8
MI. 6
LEGEND
PENSTOCK
TRIBUTARY PENSTOCKS
NEW TRANSMISSION LINE
56" PENSTOCK DIAMETERS



HANALEI HYDROELECTRIC PROJECT

PROPOSED SITE FACILITIES

Figure C-3

BINGHAM ENGINEERING

Date March 1986 Project # 608-014

EXISTING CONDITIONS

PHYSICAL RESOURCES

Climate. Kauai is located just south of the Tropic of Cancer. It enjoys a relatively mild and uniform temperature condition because of its location in mid-ocean and the small seasonal variation in the amount of energy received from the sun. Mean annual temperature is 74°F at Lihue Airport. Extreme temperatures recorded at the airport of 50°F in January and 90°F in October are representative of the seaward areas.

In contrast to the equable temperature conditions, the interaction between the moist tradewinds and the island's high mountains result in extreme variation of rainfall. Average annual rainfall in the Hanalei basin varies between 100 inches near the coastline to over 450 inches at the summit. The basin has a distinct wet and dry season. The wet season is usually from November through May (the wettest months being December through March) the dry season is from June through September (June and July).

Geology and Physiography.[1] The island of Kauai is the summit of one of the principal volcanic mountains of the partially submerged Hawaiian range.

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[1]Geologic and Engineering Geologic Reconnaissance of the Hanalei Valley. Williams, Appendix 1985.

This range extends for a distance of 1,500 miles across the Pacific Ocean floor.

Kauai is structurally the most complicated and one of the oldest of the Hawaiian islands. Basically it is a large shield volcano consisting of thousands of feet of volcanic flows of varying thickness although most are quite thin. The volume is estimated to be on the order of 1,000 cubic miles, the portion of the island above sea level is approximately 553 square miles. Volcanism is most likely Tertiary and was quite rapid. This early stage of activity is called the Waimea Canyon Volcanic Series. Near the end of this build up of flows the summit collapsed creating the largest caldera of any of the Hawaiian Island, averaging 10 - 12 miles.

After this early sequence of rapid volcanics and collapse there was a long period of erosion which allowed a thick soil sequence to develop. Then from a series of about forty vents there was a major period of renewed volcanism. This second series known as the Koloa Volcanic Series resulted in lava filling several of the large depressions along with slope failure of many of the newly developed soils. Some of these lava flows are much thicker in that they were basin fill and therefore not allowed to flow as far and develop into thin flows. Near the Hanalei River this later sequence of flows is evident forcing the channel up against the older Waimea flows re-routing the river to what is now Hanalei Bay.

Although the volcanic sequences described vary somewhat in their cycles and thickness of flows they are quite similar in lithology. They are both basically olivine basalt (calcic plagioclase with pyroxene and magnesium and iron silicate olivines). Numerous variations of these olivine basalts are described in the literature but they are refined igneous petrologic descriptions and do not play a role in siting of the Hanalei project area.

The older Waimea Canyon Series has four members, two of which are located in the project vicinity. The Napali Formation (Twn) is a sequence of thin flows of olivine basalt which accumulated on the flanks of the major sheild volcano. The Olokele Formation (Two) is comprised of thicker flows of olivine basalt with some rare andesites and andesine. These flows accumulated on the broad caldera at the summit of the big shield which explains the thicker sequence. The younger Koloa Volcanic Series has two formations in the project vicinity. The youngest is simply referenced as the Koloa Lava Flows (Qkl) and is a Nepheline (alkali rich) basalt. This flow erupted from several vents along the east side of the island. The more prominent formation is the Palikea Formation (Qkp) which consits of masses of breccia and beds of conglomerates. This formation is in direct contact with the Waimea Series in some places and is intercalated between flows of the Koloa series. The Palikea Formation is considered a sedimentary deposit. All rock units are intruded in several sections by dike swarms and other smaller intrusions. Several dikes were mapped along the intended alignment of the Hanalei project.

Project Geology. The Hanalei River flows north to the ocean from below Mt. Waialeale. The intended point of diversion is at a point on the river where several smaller tributaries come together and form the larger river section. The Hanalei River flows in a volcanic bedrock controlled channel and has been influenced near its terminus by the later Koloa flows. The Waimea Canyon Volcanics are located to the west forming the higher, steep ridges. The rocks to the east are mostly the Koloa Volcanics and the evidence of this flow in controlling the stream is quite evident. The Koloa flows have advanced from the east and have forced the flow of the river against the Waimea Canyon rocks. This has resulted in a redirection of the terminus of the river and the creation of a new delta environment. Hanalei Bay is the modern terminus west of the older one. Evidence of an older bay is not obvious and may have been partially covered up by the more recent flows.

Seismicity. Earthquakes in the islands are associated with two primary types of activity. By far the most prominent is that associated with the regional ongoing volcanic activity. Although there is no active volcanic process on Kauai, the well known Mauna Loa and Kilauea volcanos on the island of Hawaii display the overall young age and activity of the island system. The earthquake activity associated with the volcanics is definately intermittent. The most significant potential on Kauai is the structural activity associated with the deeper movement along the massive Molokai Fracture Zone within the island environment. This is a major mid-Pacific tectonic feature and the primary siesmic risk for Kauai should be evaluated based on this sytem and not the seismically active sections near the island of Hawaii. As to potential damage and the associated engineering considerations on Kauai, there is little in the recent record to use in examining this potential. An event with a Richter magnitude of 7 occurred in 1938. This event had an epicenter located on the Molokai Fracture Zone 25 miles north of Pauwela Point on the north shore of Haleakala, Maui. There were no detailed measurements available at that time and therefore the effect on the area around the Hanalei River and the Hanalei Bay cannot be assessed. A Richter magnitude 7.5 event occurred along the south coast of the island of Hawaii in 1968 and was caused by more local activity. This, one of the largest events ever recorded in the islands, was associated with local activity near Hawaii and Maui. Again the effect on Kauai was not determined in detail but the earthquake was felt in Honolulu.

In considering the overall tectonic setting of the Hawaiian Archepelago all proper seismic considerations will be used in the design of this project. The Uniform Building Code assigns a seismic risk value of 0 to Kauai for design use. For proper evaluation the worst case should be used and it would be prudent to at least evaluate the final design in accordance with the requirements of Zone 1.

Soils. As described in the geology section the long period of quiessence after the build up of the main Kauai shield (Waimea Canyon Volcanics) allowed for the development of areas of deep soils. These were in part disturbed by the renewed activity of the Koloa volcanics but there exist areas of rich, well developed soils. The extreme slopes on the island and the numerous drainages have created deep alluvial deposits from which many of the soils have developed. Some have originated in coral and basalt sands and dunes but primarily they are alluvial soils or saprolitic soils weathering in-place from the igneous rock. The type or taxonomic classification of the various soils is based on the depth of development and the degree of slope. The narrow canyons play a critical role in some drainages by confining the soils between the prominent basaltic ridges.

The Soil Conservation Service classifies ten major soil associations on the island of which only two are found along the Hanalei River. These two are the Hanalei-Kolokolo-Pakala association. This unit is a deep, full range (level to steep), poorly to well drained soil with a fine to medium textured subsoil. The other association is the most prominent on the island and is really not a soil. The USSCS classification of this is the Rough Mountainous Land-Broken Textured Land-Rock Outcrop Association. It consits of well to excessively well drained very steep precipitous land (mountains and gulches) with extensive areas of exposed igneous rock.

Within the planned construction corridor the depths are expected to average much less except near the powerhouse site. Measured soil thickness at several random locations is on the order of 1 - 2 feet except within the active channels of the Hanalei River and its tributaries. The Detailed Land Classification - Island of Kauai, from the Hawaii Land Study Bureau Bulletin No. 9 was consulted in evaluating site soils. No specific data from it is presented because it deals primarily with agricultural products of economic significance. Agriculture is not a primary concern in the majority of the project area and detail from LSB Bulletin 9 is not warranted. This is particularly valid considering the limited detail presented by the SCS for the same soils.

Hydrography. Hanalei Valley and its catchment basin forms the largest Ahupua'a (ancient land unit) in the Halele'a District of Kauai. This district with plentiful rainfall, and the most mature river systems in the Hawaiian Islands is the largest wetland agricultural area in the State. At present, Hawaiian taro is cultivated only in the lower portion of the Valley below the Hanalei Homesteads. The area of this study extends through the now uninhabited upper portion of the Valley. At the proposed power plant structure the river is at elevation 85 feet extending to 650 feet elevation at the mauka end (Ka'apoko Stream). This is a slope of 565 feet over a river mile distance of approximately 5.9 miles. The river itself along this distance has meandered across an incipient flood plain whose widest points are little over 1,000 feet. The inside of the curves form point bars which vary from 800 to 2,000 feet in length and become broader and more level downstream. In some cases, these point bars are cut along their backs by intermittent flood channels of the river. In the upper sections of the project area there are two major islands in the main channel. Based on flows, the Hanalei River is the largest river on the north shore of Hawaii.

Hanalei is a wet valley. It drains a plateau in its upper reaches with rainfall exceeding 500 inches yearly. The Valley itself has rainfall from 300 inches at the top to 150 inches near its mouth. There is plentiful evidence of seasonal flooding throughout the Valley. The channel during a flood stage has changed course in at least one place since the 1983 U.S.G.S. Quad map was completed and has cut off the wide meander mauka of Pu'u o Miki, forming an island. Other channels behind meanders show signs of frequent carrying of overflow. During flood stage prominent islands are completely under water. Flood debris was found in tree branches 8 to 10 feet above normal water levels during the March 1-2 visit to the Valley.

<u>Tributary Valleys.</u> The configuration of the tributary valleys and the contrast betwen those on the west side and east side is partly determined by differing ages of volcanic series. The Valley is formed through the contact between the older Olokele Formation on the west side and the younger (Pleistocene) Koloa Series on the east side (Macdonald and Abbott: 1970). The ridge on the west wide is higher and the tributary valleys generally steeper. However, the Isohedral liner show higher rainfall on the west wide (Armstrong, ed. 1973), particularly in the upstream areas. For this reason, although the westerward tributaries are shorter, they appear to carry more drainage.

Larger tributaries typically head at steep "Pali-like" cliffs with waterfalls. These side valleys broaden at their confluence with the Hanalei River but still maintain steep sides. The only reasonable access on foot up these valleys would be up the stream bed itself and even then only for short distances.

Some of these tributaries are named. On the east side makai to mauka are Pekoa, Kaapahu, Kaiwa and Waipunaea. All of these streams have falls and all look fairly similar from the air.

On the west side the valleys are short, steep and unnamed on the U.S.G.S. Map, except for Ka'apoko at the upward end. This valley is by far the longest on the west side of the river. Its flow is dammed high in the valley and diverted through a tunnel to the Hanalei River and then tunnelled to the Wailua drainage. An unnamed valley on the west side, opposite Kaapahu Valley, is a prominent marker from the air. It has a steep back with three high falls.

Additional hydrologic information is contained in Section B-6b of this report. The following is formation from that section quantifies the flows in the Hanalei River basin.

The total drainage area in the Hanalei Basin at gage 16103000 is 19.1 square miles. Figure B-1 (Section B-6b) illustrates the location and annual mean flow of the U.S.G.S. gaging stations in the basin. Table B-6b-1 lists the stream gaging stations operated by the U.S. Geological Survey in the Hanalei Basin.

<u>Irrigation Diversion.</u> The Hanalei River Basin is shown on Figure B-1. A description of the diversions occurring in the Hanalei Basin follows:

a. The Hanalei Tunnel conveys waters from the Hanalei River Basin into the North Fork Wailua River Basin from which the water is conveyed downstream for irrigation in the vicinity of Lihue and Kapaa.

b. Streamflows from the Hanalei River are diverted into the China Ditch approximately 1 river mile downstream from the powerhouse. This ditch is used to provide flows for agricultural uses in the Hanalei Valley.

c. Streamflows are diverted from the Hanalei River into the Kuna Ditch approximately 1.5 river miles downstream from the powerhouse. This ditch is used to provide flows for agricultural uses in the Hanalei Valley.

d. In the formulating alternatives, it was assumed that the historical diversions and the external inflows and outflows will continue.

SOCIO-ECONOMIC RESOURCES

Institutions. The State of Hawaii is governed by a bicameral legislature, a judiciary and an executive branch where power is vested in a governor. The principal executive department responsible for the management of the State's public lands, water and mineral resources, fish and game resources, forest reserves, and State parks, including historic sites is the Department of Land and Natural Resources (DLNR). The Division of Water and Land Development, within the DLNR, provides for the development of water resources, including hydroelectric power facilities. The DLNR is administered by the Board of Land and Natural Resources, headed by its chairman. As the authorized representative of the

Governor, the chairman may execute agreements, within his powers, on behalf of the State.

The promotion of long-range socio-economic development, including general planning, technical analyses, redevelopment, and employment is a function of the Department of Planning and Economic Development (DPED). The Energy Division within the DPED compiles detailed information on energy and fuel consumption, sales, generation, and shipment. In addition, DPED is charged with management of State energy research and development funds and coordination of inter-agency energy developments, including hydroelectric power.

Electric generating companies servicing the public in the State of Hawaii are governed by the rules set forth by the Public Utilities Commission (PUC) of the State of Hawaii under the Department of Budget and Finance. This commission was created and is chartered under Chapter 269, the revised laws of Hawaii 1955, as amended. The Commission examines the propriety of rates, capital expenditures, and regulates standards of electrical service. Companies generating power primarily for their own use, such as sugar companies, are not directly controlled by the PUC.

Local government is vested in the County of Kauai. The County of Kauai includes the islands of Kauai and Niihau, adjacent waters and islets within three nautical miles of their shores. The executive power of the County is exercised by the Mayor. The principal local agencies involved with hydroelectric development are the departments of Public Works, Planning and the Office of Economic Development.

The only electric utility on the island of Kauai is the Kauai Electric Division of Citizens Utilities Company whose corporate headquarters are located in Stamford, Connecticut. Approximately 60 percent (as of 1981) of the system energy is developed at the Port Allen main thermal plants, the balance being purchased energy from industrial sugar companies.

Population. Island population levels on Kauai remained relatively stable during the 1950-1970 period. In the 1970's, however, population growth was somewhat faster than had been anticipated. Hawaii Department of Planning and Economic Development (DPED) projections had predicted growth during the 70's to 36,500 by 1980. Census figures reveal that this estimate has been exceeded, as 1980 population was 39,082, about 7% higher than the forecast. The estimated resident population for 1985 was 44,800. When you add the tourist populations you get an average defacto population of 53,000. Based on percentage of increase in the population, North Shore is the fastest growing.[2] (See Tables C-4 and C-5 and C-6.) The development of the Princeville resort and residential area largely accounts for this growth.

This translates into an equivalent annual growth rate from 1970-1980 of about 2.6% compared to a growth rate for the entire State of Hawaii of about 2.3% annually for the same period. Future growth will most likely

[2]Based on personal conversations with Bill Blanchard, D.P.E.D.

TABLE C-4

SOCIO-ECONOMIC DATA

	Kauai	North Shore
1970 population*	29,524	1,182
1980 population**	38,891	2,668
Median age**	27.1	28.5
Average household size**	3.5	3.0
Median household income***	$10,750	$11,600
<u>Population Composition</u>**		
Caucasian	28.5%	51.9%
Filipino	26.2%	14.5%
Japanese	25.0%	10.9%
Hawaiian	14.6%	17.7%
Other	6.7%	5.0%

*1970 U.S. Census

**1980 U.S. Census

***Robert N. Anderson, University of Hawaii Agricultural Experiment Station, <u>1975 Kauai Socio-Economic Profile,</u> 1975.

TABLE C-5
POPULATION DISTRIBUTION ON KAUAI ISLAND, 1970-1980

CENSUS TRACTS

Year	Total Kauai	401 Hanalei	402 Wailua Anahola	403 Kapaa	404 Puhi-Hanamulu	405 Lihue	406 Koloa-Poipu	407 Eleele-Kalaheo	408 Kaumakani-Hanapepe	409 Kekaha-Waimea
1970[1]	29,524	1,182	3,599	3,794	3,642	3,124	3,141	3,660	3,173	4,159
1974[2]	29,460	1,700	4,220	3,630	3,140	3,090	2,850	3,910	2,700	4,220
1980[1]	38,856	2,668	6,030	4,467	4,590	4,000	3,879	4,855	3,111	5,256

1 State Department of Planning and Economic Development. The State of Hawaii Data Book 1981, A Statistical Abstract. November 1981.

2 Anderson, Robert N. and others. Kauai Socioeconomic Profile. Department Paper 35. Honolulu; Center for Nonmetropolican Planning and Development, Cooperative Extension Service and Hawaii Agricultural Experiment Station, University of Hawaii, May 1975, Table 9.

fall into the range of 1.4% to 2.2% annually through the year 2000, leveling off to less than one percent annual growth in the period 2000-2030. These projections are derived from DPED forecasts as well as the 1980 projections by the Bureau of Economic Analysis, U.S. Department of Commerce of non-SMSA portions of Hawaii. Population in the Lihue, Kawaihau Districts of Kauai, also rose faster in the 1970's then had been expected by DPED. By 1980, these districts had grown to a combined population of just over 19,000 about 14% higher than projected. The 1985 estimates show the Kawaihau District with the largest actual population increase, but because of its large population base the percentage of growth is not as rapid as the growth on the North Shore.[2]

North Shore residents tend to be older than the average Kauai resident, and the average household size is smaller. Four ethnic groups comprise approximately 95% of the North Shore's total population, which follows the island wide pattern. However, in the North Shore there are proportionately more Causacians and Hawaiians and fewer Japanese and Filipinos than on the rest of the island.

The median household income in the North Shore is higher than on the island as a whole. A 1980 survey indicates that approximately half of the North Shore work force is employed within the region. About 12% of the working population is employed in construction, 11% in tourism (see Table C-7), and 8% in agriculture. Over 15% is associated with various other businesses and retail sales, and 13% is retired. Approximately 6.8% of the island wide work force was unemployed in 1985.[3] A summary of

TABLE C-6
POPULATION CHARACTERISTICS BY CENSUS TRACTS
KAUAI, 1974

Characteristics	Total	Census Tracts 401	402	403	404	405	406	407	408	409
Number of households	8,550	490	1,240	1,030	800	1,210	880	1,210	800	1,110
Percentage	100	5.7	14.5	12.0	9.4	11.6	10.3	14.2	9.4	13.0
Median household size	3.2	2.75	2.89	3.04	3.75	2.85	3.00	2.89	2.50	3.40
Median household income in dollars	10,750	11,600	13,620	10,190	10,330	14,290	10,600	9,680	7,750	10,110
Median number of years of adults in the community	27.7	14.5	24.0	26.7	27.0	32.5	23.5	27.9	37.5	34.5
Adults born on Kauai in percentages	53.6	36.8	48.8	57.5	43.5	63.9	50.3	56.8	54.2	59.4
Sex										
Male	51.8	49.4	48.4	50.9	55.7	52.8	51.1	54.7	53.4	50.0
Female	48.2	50.6	51.6	49.1	44.3	47.2	48.9	45.3	46.6	50.0
Median age	27.1	23.7	26.9	24.9	23.9	28.5	27.0	29.7	35.3	24.1
Adults living their whole life on Kauai										
Yes	52.8	30.5	47.2	57.3	43.5	63.9	46.6	56.8	54.9	60.5
No	47.2	69.5	52.8	42.7	56.5	36.1	53.4	43.2	45.1	39.5

Source: Anderson, Robert N. and others. Kauai Socioeconomic Profile. Departmental Paper 35. Honolulu: Center for Nonmetropolitan Planning and Development, Cooperative Extension Service and Hawaii Agricultural Experiment Station, University of Hawaii, May 1975.

unemployment figures for the past 15 years indicates a dramatic rise from 1970 but seems to be showing a gradual reduction the last 4 years. (Unemployment rates. 1970 - 4.8%, 1975 - 9.1%, 1980 - 4.2%, 1982 - 8%, 1984 - 7%, 1985 - 6.8%.) Statewide unemployment figures indicate that unemployment tends to be higher in the construction trades than in most other occupations.

Economic Development. Hawaii is a prosperous State with a growing population and economy. Between 1950 and 1980, the total resident population increased by over 92 percent from 500,000 to 964,624. The gross state product increased over tenfold between 1950 to 1979, from $900 million to $10.3 billion. The three largest contributors to the State economy are tourism, defense expenditures and agriculture. The bulk of agricultural activity is in the production of sugar and pineapple. The most rapid growth in the past decade has been in the tourist industry. Tourist arrivals increased from 243,000 annually in 1959 to 3,934,000 in 1980. Visitor expenditures have grown by an average of over 17 percent annually since 1959, when they amounted to $109 million. Estimated 1979 visitor expenditures were over $2.6 billion. While visitor expenditures increased by a factor of 20 over this period, defense expenditures tripled. The trend in toursit industry growth will probably continue, although at a slower pace, together with the State economy in general.

Until recently, sugar was the mainstay of Kauai's economy. At it's peak, eight sugar plantations on Kauai produced over one-fifth of the State's

[3]Texeria, Herman J., Office of Economic Development, 1985 Kauai Statistical Review.

total sugarcane yield. Pineapple was at one time a major sector of the Kauai economy, but has not been cultivated since the closing of the county's last cannery in the early 1970's. The largely agrarian base of the island's economy has changed with the surge in tourism in the last decade. Sugar is still a major economic base, but tourism is now the island's leading industry. Lihue is the center of economic activity in the county, with the two major transportation facilities, Lihue Airport and Nawiliwili Harbor, located nearby. The airport at Lihue has recently undergone expansion in anticipation of continued growth in interisland traffic. There are also petroleum storage facilities situated in the Lihue area.

Major employers in the island's economy are the visitor industry and agriculture. Other important employer's are Federal, State, and County governments, as well as commercial and business services. Table C-7 shows some selected statistics for recent years for the County of Kauai.

Kauai's visitor industry has suffered the effects of three consecutive visitor years of progressively worsening visitor totals. This major sector of the economy has in turn contributed to a measurable decline in business activity in 1980. Although the unemployment rate is at its lowest level in several years, the island's economy is presently suffering somewhat of a decline. While the sugar industry might ordinarily have countered such a trend with increased production, a substantial drop in 1981 sugar prices made receipts significantly lower than in 1980. The sugar industry in the State suffered a devastating $83.5 million loss in 1981. Losses on the island of Kauai totalled approximately $22 million.

TABLE C-7

SELECTED STATISTICS, COUNTY OF KAUAI 1/

	1976	1977	1978	1979	1980	1981
Population, Resident	34,000	36,200	37,000	38,100	39,082	NA
Per Capita Personal Income ($)	5,762	6,633	7,147	7,673	8,472	NA
Civilian Labor Force	17,150	18,550	18,350	18,500	20,000	20,700 p
Employment	15,550	17,350	17,100	17,450	19,050	19,100 p
Unemployment	1,600	1,200	1,250	1,050	950	1,650 p
Unemployment Rate (%)	9.4	6.5	6.8	5.6	4.6	7.9 p
Estimated Westbound Visitors (1000's)	699.3	740.5	837.7	825.4	781.4	513.8 p
Intended Length of Stay-- Westbound (Days)	2.85	2.97	3.08	3.29	3.40	3.53
Hotel Inventory (Rooms)	3,724	3,868	4,097	4,064	4,435	5,207
Hotel Occupancy (%)	76.8	80.6	83.3	76.5	69.0	60.7
Sugar Production, raw sugar 96o (thousand tons)	217	232	223	232	223	134
Diversified Agriculture (million $)	5.3	6.5	7.4	9.5	10.4	NA
Crops	2.3	2.9	3.1	5.1	4.7	NA
Livestock	3.0	3.6	4.3	4.4	5.7	NA

NA = Not available p = preliminary

1/ From Economic Indicators, First Hawaiian Bank, November 1981 and October 1982.

However, prospects for long term prosperity and stability are encouraging. Major developers at one of Kauai's resort destinations, Poipu Beach, are well along in additional developments, and the county administration has made revival of tourism a top priority, having begun a program of heavy promotion in cooperation with the private sector and the Hawaii Visitors Bureau. Master plans are being developed for fishing and agriculture, and the Administration is pushing for high technology enterprise to strengthen the economy's base. Despite efforts to diversify and thereby further stabilize the economic growth prospects of the island, particularly in view of an uncertain sugar industry future, agriculture continues to be a dominant sector of the economy. Guava and papaya are significant areas of promising cultivation.

On 23 November 1982, Hurricane IWA struck the Hawaiian Islands causing an estimated $92 million public and private property damage on Kauai. Shortly thereafter on 27 November 1982, the President declared the State of Hawaii a Federal disaster area, enabling the Federal Emergency Management Agency (FEMA) to provide assistance. Damages blacked out the electrical system over the island and services were not restored at most communities for two weeks. Although there were no fatalities on Kauai, recovery and reconstruction operations were extensive and took many months.

Kauai has taken a step toward energy self-sufficiency by increasing its capacity to generate electric power from nonfossil fuel sources. In November 1980, Lihue Plantation Company's new bagasse-fired power plant entered the electric power generating service on Kauai. Turning sugarcane fiber into electricity, the plant produced 32 percent of Kauai's 1981 electrical energy need. Prior to this new service, only about 26 percent of the island's electricity came from nonfossil fuel sources, but the new plant has increased this level to about 44 percent for the total plantation and utility system. Kauai Electric has also been looking into the area of wind energy development. The county is considering other biomass fuel development programs involving municipal refuse, and cane trash. Kauai has also adopted an energy self-sufficiency plan, stressing conservation and efficient government energy use. There are currently seven hydroelectric plants in operation on Kauai. In addition several hydroelectric projects are proposed for the island. McBryde Sugar Company has a CDUA permit for a 3.6 mw project on the Wainiha River and Island Power Company has a CDUA permit for a 6.6 mw project on the Wailua River. In addition, Garrett-Callahan has proposed a 6.0 mw project on the Lumahai River, and Amfac is studing a 1.5 mw project known as the Kitano Hydroelectric project.

Land Use. Land use on Kauai is characterized generally by forest land covering the fairly rugged interior, with small concentrations of urban development scattered along the coastline, and agricultural development (predominantly sugarcane) in a belt adjacent to the ocean. There is neither urban use nor agricultural use on the rugged northwest coastline. The major land use, constituting over half of the island's area is forest, forest reserve, and recreation. Agricultural use accounts for another approximately 1/3 of the island. The remainder, less than 10%, is in urban and urban-related uses. This pattern of land use is generally the same for the State of Hawaii as a whole with the exception that Oahu, the major population center is more urbanized than the "neighbor islands" of Hawaii, Molokai, Lanai, Maui, Niihau, and Kauai. As with the rest of the neighbor islands, Kauai's land use tendencies give the island a rural, agrarian flavor. The Hanalei River basin is divided between conservation and agricultural land use districts. Small portions in the lower reaches adjacent to the river below the project are designated as rural and urban districts. A portion of the Hanalei River discharge is exported to the Lihue area for sugar irrigation by means of ditches and tunnels at about 365 m elevation. A smaller part is again diverted through ditches for use in the taro fields near the river mouth. Several small cattle pastures and a commercial buffalo operation are located in the middle and lower Hanalei Valley. Most of these pastures as well as most of the taro farms are within the federally owned Hanalei Wildlife Refuge. Other activities include hunting and fresh water fishing, particularly for the 'o'opu-nakea. Much of the fishing harvest, appears to be for local and home consumption rather than commercial sale. Kauai's largest and most productive taro farming area is located in Hanalei Valley.

Land Ownership. All of the lands needed for the project are owned by the State of Hawaii. No federally owned properties will be needed for the project. (See Section B-4 of this statement.)

A total of 37.9 acres of State land will be required for construction of the proposed project. The proposed project lies entirely within "Conservation District" lands of the Halelea Forest Reserve located in Hanalei District. The majority of the land is within Resource (R) Subzone and a small portion of the project lies within Protective (P) Subzone. A recent addition was made to the Halelea Forest Reserve which added 568 acres of land near the Hanalei Homesteads.

WATER RIGHTS

The water rights in the State of Hawaii are based on a series of judicial decisions since 1920. These judicial decisions reflect a particular brand of riparian doctrine orginating from nature Hawaiian "kuleana" land and water rights. In the 1974 McBryde v. Robinson case, the Hawaii State Supreme Court ruled that the State, as owner of all surplus water and land owners of appurtenant lands, cannot divert waters outside the drainage area. In effect, it mandates that the natural flow of the stream may be legally enforced as a minimum level of stream flow. The case is still under consideration by the courts. However, historically for irrigation and on Kauai, stream waters were considered owned by the land owners subject to prescriptive rights and use of water. In the specific case of the Hanalei River and its associated irrigation diversion system, land ownership is divided between the State of Hawaii in the project reach and several private homesteads in the area below the project. Above the project flows from the Hanalei River are diverted through the Hanalei Tunnel and used to supplement flows in the North Fork, Wailua River. These flows are used to provide irrigation to cane fields under lease to Lihue Plantation. Lihue Plantation maintains a water lease agreement with the State of Hawaii for the use of flows from the North Fork of the Wailua River.

If the McBryde decision is to be rendered binding, the State, both as land owners and local sponsor for this particular hydropower project, may be required to uphold conflicting positions. The diversions would be subject to cessation or control to uphold natural stream flows and in the same instance, the continuity of existing and future diversions would be necessary for sugar and hydropower development. The resolution and implementation of necessary water rights are local responsibilities.

Since the proposed project is non-consumptive in nature, a water right should not be necessary for the generation of electricity. However, the developer will request a final ruling from the State of Hawaii in this matter prior to construction and will acquire any permits necessary for construction of the project. Based on previous experience it is expected that the State will require the developer to acquire a water license from the State to use the flows from the Hanalei River.

WATER USES

The waters in the Hanalei River have a number of existing uses. The primary use of the river flows is for irrigation purposes of agricultural lands.

The Hanalei tunnel exports flows from the upper Hanalei Basin into the Wailua Basin for irrigation of sugarcane. Other diversions for agriculture are made at the China Ditch and Kuna Ditch. These ditches carry flows into the taro fields located in the lower Hanalei Valley. This valley produces Hawaii's greatest quantity of taro.

Use of the water is made by recreationalists and hunters in the area. Commercial and recreational fishing primarily take place in the lower reaches of the Hanalei River.

Flows from the Hanalei River are also used to maintain a suitable habitat for birds, mammals, and other forms of life within the Hanalei National Wildlife Refuse in the lower Hanalei Valley.

ENVIRONMENTAL RESOURCES

Water Quality. Long term water quality data for the river are available in U.S.G.S. Water Data for Hawaii (Chinn, Tateishi, and Yee 1985). During field investigations complete the survey of aquatic macrofauna in the Hanalei River. Dr. Amadel Timbol also completed a limited water quality sampling program. These one time, one season data reflect only the conditions at the time of sampling. They may be useful for comparative purposes and could be part of the pre-construction data if the proposed project is realized.

Subsurface water temperature in the 10 sampling stations ranged from 18 to 24°C. Stations at the upper elevations were about 4°C cooler than the flood plain stations. This range falls within the range of unaltered streams studied by Timbol and Maciolek (1978) and are within the tolerance of native gobies (Hathaway 1978).

Conductivity indicates total dissolved solids in water (Cole 1979). In Hanalei, conductivity ranged from 53 through 83 umhos (Table 1). The upper elevation stations have lower conductivity than the flood plain stations. The values are indicative of water with very low dissolved materials. These values are lower than those for Kauai streams which included farms within their drainage areas (Timbol and Maciolek 1978).

Results for dissolved oxygen were obtained as mg/L and converted to percent saturation. Hanalei River water is well saturated with oxygen, from the upper elevations through the middle elevations down to the flood plain stations. These results are indicative of clean, strong flowing, bubbling waters.

The pH of Hanalei River is between 7 and 8; well within the range of neutral to slightly alkaline water for normal Hawaiian streams. Organic acids from decomposing plant materials in the watershed tend to make stream water more acidic but is probably neutralized as the water flows over volcanic rock (Bright 1982).

The river empties into the Class AA coastal waters along the North Shore. Although the land along the river is classified in a State study as "lands adequately treated by a conservation program or otherwise naturally protected," the same study indicates that coastal waters off Hanalei are part of "areas with red water after storms."[4] This phenomenon occurs along the entire North Shore, where high rainfall runoff and numerous streams erode natural and disturbed slopes.

[4]State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, Statewide Silt Basin Investigation, Report No. R66, December, 1980.

Aquatic Fauna. The following section is taken from "A Survey of Aquatic Macrofauna in Hanalei River, and the Potential Impact of Hydroelectric Development" by Amadeo S. Timbol, Ph. D. 1986. This survey is included as Appendix I to this report.

Hanalei River is situated in Hanalei Valley on the island of Kauai. Its headwaters originate at an elevation of 1340 m (4420 feet) and the main channel is about 25 km (15 miles) with a slope gradient (m/km) of 54 (Timbol 1977).

The long term average discharge (1964-1984) for Hanalei River is 217 ft^3/s or 157,200 ac-ft/year (Chinn, Tateishi and Yee 1985) with October and April having the highest discharge in water year 1983 and 1984. The flow regime is irregular. A portion of the Hanalei surface flow has been exported since 1925 by way of the Hanalei tunnel at about 365 m elevation. This is upstream of the proposed diversion weir for the Hanalei hydroelectric project. Another smaller portion is diverted by way of the Kuna and China ditches for use in the taro fields near the river mouth. Some cattle and horse pastures are located in the middle and lower Hanalei Valley. Most of these pastures and two farms are within the U.S. Fish and Wildlife Service Hanalei Wildlife Refuge. Native waterbirds are abundant in the refuge. The alien bird, cattle egret (Bubulcus ibis) is also seen flying in and out of the valley.

Hanalei River is one of the few streams which support an ethnic (goby) fishery. For example, during one freshet day (August 23, 1986), the 'o'opu-nakea (Awaous stamineus) were on spawning migration. At eleven in the morning of the next day, I counted 49 persons pole fishing for the goby along the river banks in the vicinity of Hanalei bridge. Gill nets set to harvest the spawners numbered six: three by the rice mill, two by the Hanalei bridge and one just upstream of the Dolphin restaurant. One group of 15 pole fishers caught 11 spawners in 10 minutes.

The river is one of seven streams on Kauai in the Nationwide Rivers Inventory, a listing of the Nations significant relatively natural and free-flowing streams (The National Park Service 1982). It is described as "extremely photogenic".

Sampling Stations

Ten sampling stations were established. Three stations (Stn. 1, 3) are upstream of the proposed diversion weir for the hydroelectric facility; station 2 is in an unnamed (Kaawaawi) tributary. Five stations (4-8) are between the proposed weir where streamflow will be diverted and the proposed powerhouse where the water will be released to the mainstream channel. Two stations (9, 10) are downstream of the proposed powerhouse. Stations 1 through 3 are referred to as upper elevation stations, 4 through 8 as middle stations and 9 and 10 as flood plain or lower elevations. Distances mentioned in the description of sampling stations are in terms of channel lengths measured from U.S.G.S. topographic maps.

Biological

The macrofaunal component of Hawaiian stream biota is composed of species which are readily recognizable and can be collected or enumerated by established methods. The planned construction and operation of a hydroelectric facility in Hanalei Valley requires that emphasis should be given to the endemic diadromous organisms. A more extensive discussion on Hawaiian stream fauna is available in Timbol (1977). Diadromous animals are those that spend their entire adult life in fresh water but their larvae must reach the ocean to develope and re-enter streams as post larvae. To this group belong all the native freshwater gobies, the endemic mollusk hihiwai, and the endemic mountain shrimp, 'opae-kala'ole. The alien Tahitian prawn is also diadromous.

The life history of the 'o'opu-nakea is a good illustration of diadromy in Hawaiian streams. This endemic goby had been studied by Ego (1956) and its life cycle is illustrated in Timbol and Heacock (1986). In August through December, the 'o'opu-nakea migrate downstream and deposit their eggs on stones near the mouth of streams. The eggs hatch within a day and the larvae are carried out to sea by water current where they spend between 5 and 7 months as part of the marine zooplankton. They then return to stream months and start upstream migration to their places of permanent residence where they attain sexual maturity.

<u>Species Inventory</u>

At least 25 species of macrofauna were found in Hanalei River and a tributary, Kaanaawi. The organisms include two annelids, six insects, two mollusks, three crustaceans, ten fishes and two amphibians. The scientific and local names, their origin and their listing are summarized in Table C-8. Twelve species are endemic, two are indigenous, eight alien

TABLE C-8

List of aquatic macrofauna in Hanalei River and Kaanaawi tributary, island of Kauai. (September - October 1986)

Scientific Name	Local Name	Origin[1]	Listing[2]
Annelids (worms)			
Hirudinea	leech	unknown	none
Oligochaeta	earthworm	unknown	none
Insects			
Diptera:			
Chiromonidae	midge larvae	endemic	none
Ephydridae	brinefly larvae	endemic	none
Tipulidae	cranefly larvae	endemic	none
Odonata:			
Megalagrion heterogamius	damselfly naiad	endemic	none
Trichoptera:			
Cheumatopsyche analis	caddisfly larvae	alien	none
Oxyethira maya	microcaddisfly larvae	alien	none
Mollusks (snails)			
Erinna aulacospira	pond snail	endemic	none
Neritina granosa[3]	hihiwai	endemic	depleted on Oahu (Maciolek 1978)
Crustaceans (prawns and shrimps)			
Atya bisulcata[3]	'opae-kala'ole	endemic	none
Macrobrachium grandimanus[3]	'opae-'oeha'a	endemic	none
Macrobrachium lar[3]	tahitian prawn	alien	none
Fishes			
Awaous genivittatus	'o'opu-naniha	indigenous	none
Awaous stamineus[3]	'o'opu-nakea	endemic	special concern (Deacon, *et al.* 1979); depleted (Miller 1972)
Electris sandwicensis[3]	'o'opu-okube	endemic	none
Gambusia affinis	mosquitofish	alien	none
Kuhlia sandvicensis[3]	aholehole	endemic	none
Lentipes concolor[4]	'o'opu-alamo'o	endemic	special concern (Deacon, *et al.* 1979)
Mugil cephalus[3]	ama'ama, mullet	indigenous	none
Sarotherodon mossambica[3,5]	tilapia	alien	none
Sicyopterus stimpsoni	'o'opu-nopili	endemic	special concern (Deacon, *et al.* 1979)
Xiphophorus helleri	swordtail	alien	none
Amphibians (frogs)			
Rana catesbeiana	bullfrog tadpoles	alien	none
Rana rugosa	greenfrog tadpoles	alien	none

1 Terms used in this column: endemic = occuring naturally in Hawaii only; indigenous = occuring naturally in Hawaii and also elsewhere; alien = brought to Hawaii either intentionally or accidentally by man.
2 Considered as endangered or threatened in official register or scientific publications.
3 Has some economic use.
4 Recommended for recognition as endangered (Maciolek 1977).
5 *Tilapia melanopleura* is known to be established in Kauai streams also.

and two are of unknown origin. Six of the endemic species, one indigenous fish, one alien crustacean and one alien fish have some economic importance. The most valuable is the endemic goby, Awaous stamineus ('o'opu-nakea) since is supports a minor ethnic fishery.

Compared with an earlier study (Timbol 1977, p. A-7) this 1986 survey lists six more species. The number is not significant. The 1977 study does not include the earthworm and the two species of amphibian tadpoles. Another insect larva may also have been there in 1977 but was not recognized. The significant difference between the two studies is the presence of the endemic goby, Lentipes concolor ('o'opu-alamo'o) and the mosquitofish, Gambusia affinis. It is highly probable that the 'o'opu-alamo'o was also present in 1977 but was not collected. That it was collected this time reflects on the collectors' improved skill on electroshocking techniques and increased awareness where the 'o'opu-alamo'o might be collected in a stream. As for the alien mosquitofish, it may have established itself after 1977 or it may have been already there in 1977 but in very low numbers to have been missed at that time.

Of the 25 resident species, only four (all endemics) are listed in scientific publications as depleted and/or special concern. These are endemic mollusk, hihiwai (Neritina granosa), and three endemic gobies; 'o'opu-nakea, 'o'opu-alamo'o, and 'o'opu-nopili Sicyopterus stimpsoni). The first two species are sometimes sold commercially. None, however, is listed as rare or endangered under the Federal Rare and Endangered Species Law. Capsule life histories of these four are shown below.

1. Neritina granosa (hihiwai)

This diadromous Hawaiian endemic grows to 6 cm shell diameter and the largest endemic neritid. It prefers clear water, bouldery, steep gradient streams. As in the diadromous gobies, the hihiwai breeds in fresh water, the larvae are swept passively to the ocean where they undergo transitional larval development as marine plankton. They reappear at stream mouths as prejuveniles and migrate upstream. Extensive information regarding the biology of the hihiwai is in Ford (1979).

During this study, we found only prejuveniles (1-3 mm diameter) in the higher elevation stations 1 and 2. Don Heacock, DLNR Aquatic Biologist on Kauai (perconal communication, Dec. 19, 1986) found three larger specimens sometime in 1985 "after hours of looking for them" at a middle elevation station (station 7, 37 m elevation).

The hihiwai has been utilized for food since early Hawaiian days and is still harvested commercially. These snails are occassionally sold in supermarkets in size averaging 25 mm shell diameter (range 15-30 mm). According to Ford (1979, p. 57) a 15 mm hihiwai weights about 0.5 gram and a 30 mm about 2.45 grams. The last reported price was $5.99/lb at Big Save in Kapaa on August or September 1982 (Don Heacock, verbal communication, December 19, 1986). Maciolek (1978) considers this neritid snail as depleted.

2. Awaous stamineus ('o'opu-nakea)

This is the largest of the endemic gobies, reaching a minimum of over 30 cm standard length (SL) in Kauai streams. In Hanalei, our samples ranged between 2 and 33 cm SL. Ego (1956) reported then in Wainiha River as far inland as 11,000 m (36,090 ft) at 450 m (919 ft) elevations with greatest densities at between 3,000 and 5,000 m (9843-16, 405 ft) from the stream mouth. This species is well known for downstream migrations usually in association with freshets or flash floods. Spawning occurs near the mouth of rivers and streams. It requires between 0.00 and 0.45 ft/s with optimum at less than 0.6 ft/s and depth optimum at about 1.6 ft (Kinzie, et al. 1984). The 'o'opu-nakea is sometimes sold commercially, the last sale at Kapaa Big Save was in September 1986 at $9.89/lb.

3. Lentipes concolor ('o'-opu-alamo'o)

The 'o'opu-alamo'o is the rarest of the Hawaiian stream fishes (Maciolek 1977, Lau 1973). In the Hawaiian folklore, to find 'o'opu-alamo'o in a net when fishing for other fish is bad luck for it keeps other fish away. This fish is regarded as kapu (forbidden) by Hawaiians who believe it is related to the Mo'o (lizard gods) (Titcomb 1972).

'O'opu-alamo'o which grows up to 10.0 cm (Lau 1973) is an almost scaleless fish which exhibits sexual dimorphism. During breeding season, the male is jet black anteriorly and bright red-orange posteriorly. Females exhibit only brown color on its entire body. Although this fish is disdromous, there is evidence that it does not undergo downstream migration for spawning purposes (Nishimoto and Fitzsimmons 1986). This goby requires a flow velocity between 0.00 and 0.31 ft/s with optimum at less than 0.5 ft/s and depth below 1.5 ft (Kinzie et al. 1984).

4. Sicyopterus stimpsoni ('o'opu-nopili)

This small (up to 15 sm SL) diadromous endemic goby also exhibits sexual dimorphism. The males are dark olive-gray or nearly black and the females blue-green to blue-grey. In early Hawaiian days, the 'o'opu-nopili was greatly relished for food, and was a favorite fish with the priests. It is also considered to bring good luck (Titcomb 1972). According to Titcomb (1972) the largest 'o'opu-nopili (up to 18 cm SL) were found in Kauai streams, particularly in Wainiha, Hanalei and Makaweli. During this survey, the specimens we caught ranged between 2 and 15 cm SL.

This species has been recommended by Timbol and Maciolek (1978) as an indicator species. Its decline in population density, or in extreme cases, its disappearance from a stream is a good indication of serious stream degradation. The 'o'opu-nopili requires 0.95 and 1.25 ft/s flow velocity with the best at less than 0.7 ft/s and depth at less than 1.5 ft (kinzie et al. 1984). Extensive information on the biology of the 'o'opu-nopili is available in Tomihama (1972).

Distribution and Relative Abundances

The purpose of semiquantitative sampling is to determine the relative abundance of each species in a standardized manner so that the seasonal and temporal changes in numbers can be measured. Table C-9 summarizes the distribution and relative abundances of macrofauna collected in the river.

Not all 25 species found in Hanalei River are found in all stations. There are lesser number of species at the upper stations and the number

TABLE C-9

Distribution and relative abundances of aquatic macrofauna in Hanalei River and Kaanaawi tributary, island of Kauai. (September - October 1986)

Scientific Name	Sampling Stations									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Annelids (worms)										
Hirudinea	0	0	0	+	0	0	+++	++	0	++
Oligochaeta	0	0	0	0	0	+	0	0	0	+
Insects										
Diptera:										
Chironomidae	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Ephydridae	0	+	+	+	0	0	0	++	+++	+++
Tipulidae	0	+	+	0	0	0	+	+++	0	0
Odonata:										
Megalagrion heterogamius	+++	++	++	0	0	0	0	0	0	0
Trichoptera:										
Cheumatopsyche analis	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Oxyethira maya	+++	+++	+++	++	++	+++	++	+++	++	+++
Mollusks (snails)										
Erinna aulacospira	+	0	0	0	0	0	0	0	0	0
Neritina granosa	++	+	0	0	0	0	0	0	0	0
Crustaceans (prawns and shrimps)										
Atya bisulcata	+++	+++	+++	+++	+++	+++	+++	++	++	+++
Macrobrachium grandimanus	0	0	0	0	0	0	0	+++	+++	+++
Macrobrachium lar	0	0	0	++	++	++	++	+++	++	+++
Fishes										
Awaous genivittatus	0	0	0	0	0	0	0	0	++	++
Awaous stamineus	++	+++	+	++	+++	+++	+++	+++	++	++
Eleotris sandwicensis	0	0	0	0	+	0	0	0	+++	++
Gambusia affinis	0	0	0	0	0	0	0	+++	0	0
Kuhlia sandvicensis	0	0	0	0	0	0	0	0	+++	+++
Lentipes concolor	0	0	+	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	++	++	++
Sarotherodon mossambica	0	0	0	0	0	0	0	0	++	0
Sicyopterus stimpsoni	++	++	++	+	+++	++	++	+++	0	0
Xiphophorus helleri	0	0	0	++	++	0	0	0	+++	++
Amphibians (frogs)										
Rana catesbeiana	0	0	0	0	0	0	0	++	++	+++
Rana rugosa	0	+	+++	+++	+++	+++	0	+++	++	0

Abundances: +++ = abundant; ++ = common; + = uncommon; 0 = absent or not seen. Refer to methods and materials section for numerical equivalences.

increases (from 9 to 16) as one proceeds downstream to the flood plain. Five species are found in 9 or all 10 stations. These are: two alien insect larvae (Cheumatopsyche and Oxyethira), one endemic insect larva (Chiromonidae), one endemic shrimp ('opae-kala'ole); two endemic gobies ('o'opu-nakea and 'o'opu-nopili). With minor exceptions, all five ubiquitous species were abundant. A seventh species, the amphibian Rana rugosa tadpole may be present in all stations although we have not collected them in stations 1, 7 and 10 at this time.

The insect macrofauna component consists mostly of Cheumatopsyche, Oxyethira and Chiromonidae larvae. Insect larvae are very important intermediaries in the utilization of plant materials and recycling of nutrients in aquatic environments. They are a major food source for fish and they may be used to determine the well-being of those fish populations. According to Platts, Megahan and Minshall (1983) insect larvae are useful for determining environmental disturbances because they have limited mobility and therefore will reflect conditions in the immediate vicinity. Insect larvae also have short life span. Their characteristics are a function of conditions during the relatively recent past.

The mollusks component of the macrofauna were found only the upper stations during this study. They were not found in large numbers. The economically important neritid mollusks, hihiwai, has been discussed in the preceding section.

The crustacean component consists of three species: two endemics and one alien. All three have some economic values. The endemic shrimp 'opae-kala'ole, is abundant in all 10 stations. They are largest (mostly adults) in the upper stations, medium size (young adults and juveniles) and very small (mostly postlarvae and juveniles) in the flood plain stations. This shrimp is harvested by local residents for food. The second endemic crustacean, 'opae'oeha'a, is found in abundance in the flood plain stations and was absent in the middle upper stations. It is gathered for use as bait. The third crustacean, the alien Tahitian prawn, is found only in the middle and flood plain stations. They are found in lower abundance as compared with 'opae-kala'ole and 'opae-'oeha'a but since the Tahitian prawns are very much larger than the first two, the Tahitian biomass is significant. Tahitian prawns are harvested by local residents for food.

The fish component of the macrofauna is the most siginificant because of the endemicity and commercial value of the 'o'opu-nakea. This endemic, economically important goby was found in all but the highest of collecting stations (Station 1). It is found in greater numbers in the middle sampling stations than in the upper and flood plain stations. This distribution and abundance is the same as that found in Wainiha River (Ego 1956): higher abundance in the lower elevations. The 'o'opu-nopili can be found in all the stations except those in the flood plain stations. The 'o'opu-alamo'o was found only in the upper elevations, upstream of the proposed diversion weir for the hydroelectric facility but downstream of the existing Hanalei ditch diversion weir. This is the first time that the 'o'opu-alamo'o has been caught in Hanalei. That only one was caught (in Station 3) confirms the earlier findings of Lau (1972) and Maciolek (1977) that this goby is the rarest of the Hawaiian endemic stream gobies.

The amphibian component of the macrofauna consists mainly of tadpoles. The almost ubiquitous R. rugosa tadpoles is probably a food organism for fish. The adult has no economic value. The bullfrog tadpoles, R. catesbeiana, have been found only in the flood plain stations. The adults can be heard croaking along the banks. The bullfrog is a desired food organism but local residents claim that there are not enough in the area to justify time spent in collecting them except once in a long while.

Flora. The vegetation on the project area presents a mosaic of different vegetation types, principally the result of past disturbances and of topographic features. A detailed Botanical Survey of the Hanalei Valley "Botanical Survey, Hanalei River Hydroelectric Project, Hanalei District, Island of Kaua'i" was completed in 1986 by Winona Char and is included as Appendix II in this report.

Much of the vegetation found on the proposed Hanalei Hydroelectric project area has been disturbed to some degree in the past. The lower half of the project area, from the proposed power plant site to about just below Pekoa Falls, is dominated largely by introduced plant species. The valley is widest in this portion of the project area with many more or less level areas along the river. Traces of former occupation or use by the early Hawaiians is evident. Plants of taro (Colocasia esculenta), 'awa (Piper methysticum), mai'a or banana (Musa sp.), and 'ohi'a-'ai or mountain apple (Syzygium malaccense) are occasionally encountered. More recent disturbances are indicated by abandoned cattle fences and pastures.

Rather dense stands of guava (Psidium guajava) forest and scrub are abundant along the river. Small patches or scattered trees of Java plum (Syzygium cumini) are also commonly observed. Large stands of bamboo (Schizostachyum glaucifolium?) and rose apple (Syzygium jambos)/bamboo forests are found near the power plant site. Scattered forests of hau (Habiscus tiliaceus), a native species cultivated by the Hawaiians, can be found in some places along the river's edge. Ground cover is composed largely of introduced grasses, ferns, and herbs such as Californiagrass (Brachiaria mutica), Hilo grass (Paspalum conjugatum), sword fern (Nephrolepis multiflora), downy woodfern (Christella dentata), and honohono (Commelina diffusa).

Parts of the valley bottom, especially along the streamside, were no doubt cultivated at some time by the Hawaiians. Plants introduced or used by the Hawaiians are occasionally encountered on the project area.

The upper one-half portion of the project area is the least disturbed, the vegetation along the bottom of valley and along the streamside is a mixture of native and introduced plant species.

In the upper half of the project area, above Pekoa Falls to the intake site, the valley narrows; in some places the steep valley walls come down to the river's edge. The steep slopes of the valley are covered primarily by 'uluhe or false-staghorn fern (Dicranopteris linearis) and scattered 'ohi'a trees (Metrosideros collina ssp. polymorpha).

The vegetation in the upper section of the project area has been subject to less disturbance, as a result, the numbers and kinds of native plant species increases. The composition of the vegetation gradually changes from one dominated by introduced plants to a mixed native/introduced forest association. 'Ohi'a trees are abundant. Some other native species found here include papala-kepau (Pisonia umbellifera), hame (Antidesma sp.), mamaki (Pipturus sp.), akoka (Boehmeria grandis), 'ama'u (Sadleria cyatheoides), kawa'u (Ilex anomala), and olomea (Perrottetia sandwicensis).

Threatened or Endangered Species. No offically listed, proposed, or candidate Threatened or Endangered plant species (U.S. Fish and Wildlife Service 1980) were found during the course of this survey.

The status of the two mamaki species (Pipturis helleri, Pipturis kauaiensis) found during this survey is considered "uncertain," i.e., insufficient information available to determine if endangered, by Fosberg and Herbst (1975). However, both species occur in the native forests on the Wai'ale'ale plateau and in many deeply dissected valleys. Recently collected specimens can be found in herbarium collections. On the project site, the plants generally occur as scattered individuals. The plants are more numerous along the river above the project site.

Avifauna and Mammals.[5] There are no endemic amphibians or land reptiles in the Hawaiian Islands. All, therefore, have been introduced (either intentionally or accidentally) by man. None are endangered species and none are of significance for an Environmental Impact Assessment study.

Amphibians

1. American Bullfrog, Rana catesbeians

This "was probably one of the first species of amphibians to be introduced into the Hawaiian Islands and may have been one of the frogs that was imported prior to 1867." Bullfrogs are serious predators on the small downy young of the endangered Hawaiian waterbirds.

2. Wrinkles Frog, Rana rugosa

This frog was introduced to Hawaii from Japan in 1986 (McKewon, 1978). It is most common in mountain streams. The wrinkled frog is common in the river at higher elevations.

3. Giant Neotropical Toad, Bufo marinus

This toad was first introduced to the islands in 1932, "when Dr. C.E. Pemberton brought 148 adult toads from Puerto Rico. "In a little over two years more than 100,000 descendents of the original stock were distributed through Dr. Pemberton's activities throughout the islands."

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[5]The following section has been excerpted from "Tetrapod Vertebrates of the Lower Hanalie River", Andrew L. Berger, 1986. This report is printed in its entirety in Appendix III in this report.

This toad is "the commonest species of amphibian" in Hawaii. These toads are active primarily at night, and is undoubtedly found along the Hanalei River.

Reptiles

1. Blind Snake, Typhlina bramina

"This small, secretive snake was apparently introduced from the Phillipines in the dirt surrounding plants that were brought in for landscaping the campus of the Kamehameha Boys School in Honolulu. These blind, worm-like snakes are rarely seen until they are flooded from underground burrows by heavy rains or unless one looks for them under branches and leaf litter on the ground.

2. Skinks and Geckos

Eight species of skinks (family Scincidae) and geckos (family Gekkonidae) are found on Kauai, although one species (azure-tailed skink, Emoia cyanura) is now thought to be rare there.

Birds of the Lower Hanalei River System

Three general groups of birds occur in the Hawaiian Islands: 1) Endemic birds are those that are unique to Hawaii and occur naturally nowhere else in the world (Berger, 1981); 2) Indigenous or Native birds, those whose total range in the Pacifica Basin includes the Hawaiian Islands; and 3) Introduced or alien birds, those brought to the islands by man. I refer to the "Lower Hanalei River System" because our observations were made from approximately 1,250 feet downward.

Endemic Birds

Koloa or Hawaiian Duck, Anas wyvilliana

This endangered species occurred on all of the main islands except Lanai and Kahoolawe into the 1940's. Birds inhabit both lowland areas (e.g., the Hanalei taro patches and the refuge) and mountain streams.

Pueo or Hawaiian Short Owl, Asio flammeus sandwicheniss

The Pueo is a permanent resident on all main islands. On Kaui it has been found in relatively dry areas as well as in the 'ohi'a rain forest and the upper reaches of the Waialae stream. The steep slopes along the sides of the river may provide nesting habitat for the Pueo.

Hawaiian Honeycreepers

This is Hawaii's unique bird family. However, approximately 40 percent of the species are extinct and another 40 percent are classified as threatened or endangered. The vast majority of honeycreeper species occur well above 1,000 feet on Kauai: for example, at Kokee State Park and the Alakai Swamp region. No honeycreepers were seen during two days along the Hanalei River, however, two species have been seen along the Wainiha River during December, 1982. Mosquitos and avian malaria is likely the main reason the birds are restricted to the high elevations now. Dewatering the river could increase mosquitos habitat by creation of more stagnant pools. Winds may carry the mosquitos, into the uplands.[6]

Amakihi, Hemignathus virens stenjnegeri

The Amakihi was described scientifically in 1782, but the first nest of the Kauai race was not found until 1964 (Berger, 1981). The species is most common in the 'ohi'a forests of the Kokee and Alakai Swamp regions (Richardson and Bowles, 1964).

Apapane, Himatione sanguinea

This undoubtedly is the most abundant of the surviving species of honeycreepers. This species typically inhabits 'ohi'a-koa forests.

In any event, the proposed project may have no adverse effect on any honeycreepers because the large number of introduced plant species up to, and beyond, the 1000 foot elevation may not provide adequate habitat for the nesting activities of these birds, and the majority of Kauai honeycreepers inhabit 'ohi'a-koa forests well above 1000 feet elevation. Newells Shearwater (threatened), Dark-rumped petrel (endangered), Bank-rumped, Petrel, and the Storm White Tailed tropic birds are also likely to occur in the area.[6]

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[6]Tom C. Telfer, Kauai District Wildlife Biologist, Division of Land and Natural Resources, Division of Forestry and Wildlife. July 8, 1986 memorandum.

Indigenous Birds

These birds are native to the Hawaiian Islands but are not unique to them. In this category are 22 species of sea birds, the Hawaiian Black-crowned Night Heron, Newell's Shearwater (threatened), White Tailed Tropic, and a number of migratory species that spend their winter or nonbreeding season in the islands have been found in the upper reaches of the Hanalei River.[6]

Order Charadriiformes, Family Scolopacidae, Sandpipers, Curlews, and Snipe

1. Wandering Tattler, Hetersscelus incanus

This species is a regular winter resident in the Hawaiian Islands.

Family Charadriidae, Plovers

Introduced or Alien Birds

Order Ciconiformes, Family Ardeidae, Herons and Egrets

1. Cattle Egret, Bubulcus ibis

Order Galliformes, Family Phasianidae, Pheasants, Quail, Francolins

2. Ring-necked Pheasant, Phasianus colchicus

"Ring-necked pheasants, lace-necked doves and barred doves may be found in the area.

Order Columbiformes, Family Columbidae, Pigeons and Doves

3. Lace-necked or Spotted Dove, Streptopelia chinensis

The species now is common to abundant on all main islands and, like the other doves in Hawaii, is classified as a game bird.

The Lace-necked Dove is common in residential areas, in dry kiawe habitat, in pasture and agricultural land, forested areas, and in open areas in the mountains. They are also found in the Alakai Swamp.

4. Barred Dove, Geopelia striata

It has been a remarkably successful introduction and it now is abundant on all of the islands.

Doves avoid dense forests; they are common in residential areas, cutover fields, pasture, and along jeep trails wherever there is a supply of weed seeds. It occurs in the lower regions of the valley.

Order Stigiformes, Family Tytonidae, Barn Owls

5. Barn Owl, Tyto alba pratincola

Barn Owls were brought to the islands (1958 through 1963) in the hopes that they would control rats in the sugarcane fields. Barn Owls in Hawaii often roost and nest in small caves on steep cliffs.

Order Passeriformes, Family Timalidae, Babblers and Laughing-Thrushes

Medolious Laughing-thrush, Greater Necklaced Laughing-thrush, Linnet, Rice Bird, Red Cardinal, Red-billed Leiothrix.

The species was first imported from San Francisco for liberation on Kauai in 1918; birds from the same source were released on Oahu in 1928, and that same year other birds were imported from the Orient and released on Oahu. This species is generally very hard to find on Kauai.

Family Turdidae, Thrushes and Bluebirds

6. Shama, Copsychus malabaricus

Family Zosteropidae, White-eyes and Silver-eyes

7. Japanese White-eye, Zosterops j. japonicus

Family Sturmidae, Starlings and Mynas

8. Common Indian Myna, Acridotheres tristis

Mammals

Endemic Mammals

The only endemic Hawaiian land mammal is the Hawaiian bat (Lasiurus cinereus semotus) (endangered), a subspecies of the American hoary bat. The Hawaiian bat occurs primarily on the island of Hawaii but is quite abundant on Kauai.

Introduced Mammals

Many of these alien species have proven highly detrimental to man, his buildings, products, some of his agricultural crops, as well as to the native forests and there animal life. Hunting of many of these species provide public recreation in the upper Hanalei region.

Some of these mammals were first brought to the islands by Captians Cook and Vancouver. Feral cattle, goats (Capra hircus), sheep (Ovis aries), and pigs (Sus scrofa) have been destroying the Hawaiian forests since 1800, and they continue to do so today. Pig trails, wallows, and other signs were conspicuous at all elevations along the Hanalei River.

With the possible exception of the house mouse (Mus musculus), all of the smaller introduced mammals prey on birds and their nests and eggs. These small mammals include the roof rat or black rat (Rattus rattus), Polynesian rat (Rattus elegans), Norway rat (Rattus norvegicus), as well as feral cats (Felis catus), and feral dogs (Canis familiaris).

Cultural and Historical Resources.[7] Hanalei Valley represents the largest Ahupua'a in the District of Halele'a on the Island of Kauai. Ahupua'a refers to the traditional land divisions that were basic units of social, economic, and political life in the pre-contact Hawaii.

> "Ideally an Ahupua'a land section stretched in a wedge from its apex at a mountain top to its base in the sea, thereby including within its boundaries all environments necessary for a self-sustaining community. Again ideally, the inhabitants of an Ahupua'a were related by blood and through children, and could claim some degree of relationship to the chiefly family to whom the Ahupua'a had originally been assigned." (Barrere 1970:3)

The traditional or pre-contact period is not well documented for Hanalei Valley, especially the upper portions of the Valley. However, recent studies, beginning with Earle (1973) and including Cleghorn (1929), Schilt (1980), and Athens (1983) produce a general outline or probable pre-contact sequence.

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[7]Hammatt, Hallett H., Ph. D. and Borthwick, Douglas, B.A., Archaeological Reconnaissance of Upper Hanalei Valley Halele'a, Kauai, Cultural Surveys Hawaii, October 1986. See Appendix IV to this report.

I. Initial settlement period; possibly around the 6th or 7th century A.D. This period was probably characterized by a coastal settlement with a marine oriented economy; however, there was probably some habitation and the beginnings of agricultural activity in the Lower Valley.

The evidence for this is an A.D. 660±95 date at Site D10-12 (Schilt 1980), which, as secondarily deposited charcoal "is suggestive of burning for forest clearance for shifting agriculture" (Athens 1983:31)

II. Semi-permanent to permanent settlements: This period was probably characterized by expansion of resource bases to both a marine and agricultural resources with permanent habitational sites in the Valley. The evidence for this is also from Site D10-12 where a stone tool assemblage, three possible post molds, and basaltic glass artifacts were found. The number and diversity of the artifact assemblage suggest permanent habitation dating to around the 13th and 14th centuries A.D. (Athens, 1983).

III. Permanent settlements and intensive irrigated agricultural complexes: This period would be charactertized by expansion of high yield, possibly surplus oriented, pondfield taro production. Permanent settlements or house sites would be on non-irrigated lands, knolls, ridges, etc., which were not "prime" agricultural areas. This period, ca. A.D. 1500 to contact, probably saw expansion into an intensive use of upper Hanalei Valley, as evidenced by the number of sites reported by Bennett and seen on the present reconnaissance. The intensive use of the upper valley was possible not until late in this period, ca. 18th century A.D., as prime lands, wide alluvial flood plains, would have been used first.

The post contact period in Hanalei has been relatively well documented in a number of historic sketches. These include E. H. Wilcox (1917), Earle (1973 and 1979), Hammatt and Folk (1979), Schilt (1980), and Carol Haraguchi's work in relation to the placement of the Haraguchi Rice Mill on the State Historic Register and making it a museum. Schilt offers the most concise historic background sketch, and the following is a short summary of that work (Schilt, 1980:5-8).

In general, foreign influence started in 1816 with Dr. Schaffer, a Russian, getting the deed to Hanalei Valley. However, this was very short-lived. In 1824 Kauai comes under the contact of the Kamehameha dynasty with Hanalei being held in trust for Liholiho. In 1834, the first mission (American Board of Missions) on the windward side of Kauai was established at Waieli. Also in the 1830's foreign plantations of sugar, silk and coffee were started and by the late 1840's there was approximately 1,000 acres of Hanalei in coffee. Population declined during this period, with the area experiencing low birth rates and moderately high death rates. The late 1840's saw shipments of goods to California, especially oranges, for the increased population there, which was due to the "Gold

Rush". In the 1850's there was a drought and blight, which damaged the coffee crops. This was the time of the major land redistribution termed "The Great Mahele". From the 1860's to early 1900's population began to increase, due mainly to the influx of Oriental laborers for the large plantations. During this time, taro, coffee and sugar were being replaced in Hanalei Valley by rice, which was not only for local consumption but exported to the western continental United States. As the price of rice fell, due to cheaper foreign competition, taro, as a cash crop, made a comeback. Presently there are about 12 tenant farmers growing taro on the broad flood plain in lower Hanalei Valley.

Archaeological Background

Archaeological investigations of Hanalei began with W. C. Bennett in 1928-29 as is reported in Archaeology of Kauai (1931). Bennett lists five sites - 139, 140, 141, 142, and 143 as being within the Ahupua'a of Hanalei. Sites 141, 142, and 143 are described, in their relation to the present reconnaissance, in a separate section of this report.

"Site #139: Po'oku Heiau, on the east bluff of Hanalei Valley a short distance from the government road on a knoll marked on the map as Po'oku. Only a few stones remain to mark the location of this heiau which Thrum describes as "An unenclosed heiau of about two acres in area. Of Luakini class, terraced down on all sides from the central platform". (Ibid. 134).

Site #140: Kapaka, on top of Kapaka Hill on the east bluff of Hanalei Valley just within the forest line. Thrum describes this structure as "A paved open platform heiau without walls; stones set edgewise traverse through. Kane its Diety. Said to have had connection with Kapinao at Waiakalua in its workings". This side has had many stones removed, or covered over with vegetation. The river stones seem to cover the top of the hill for a diameter of 75 feet. The extent of the heiau could not be accurately determined.

The stones set edgewise traversing through could not be found". (Ibid: 143).

Other archaeological work includes Earle (1973) and (1978) which dealth with the Halele'a District in general. The emphasis of his work is on irrigated agricultural complexes and their implications to social organization. The 1972 statewide inventory of sites located four sites, two fishponds, an auwai, and the Russian fort, Fort Alexander, in the makai area of Hanalei Valley. In 1979 Cleghorn conducted an extensive survey of most of the Hanalei Wildlife Refuge. The survey reports some twelve (12) sites both of prehistoric and historic age determinations. In 1980 Schilt conducted survey and test excavations, in "specified" areas of the Wildlife Refuge, "to determine the potential impacts upon archaeological resources of the proposed construction of an irrigation pipeline and access roads in the refuge." In 1981, Hammatt, Ida, and Folk conducted a survey of Kamo'omaika'i Fishpond at the mouth of Waile'ia Stream, where it enters Hanalei Bay, next to Hanalei River. This fishpond was one previously located in the 1972 Statewide Inventory KA-D10-9. In 1983 Athens conducted archaeological excavations at Site DA-D-10-12, first located by Cleghorn in 1979, then tested in 1980 by Schilt. Athens' work "revealed two stratified pondfield layers . . . The lower layer . . . produced three late radiocarbon dates, indicating that pondfield construction and use occurred during the 18th century." (Athens 1983:i) Also "Basaltic glass samples from this lower layer date to the late 13th and early 14th centuries, indicating an occupation prior to pondfield construction." (Ibid.)

Summary and Significance Evaluations

A total of fourteen site areas were located in this reconnaissance survey. Summary information on these areas is presented on Table C-10.

Generally there are three types of sites: 1) rock shelters, 2) historic house sites, and 3) agricultural terraces, some with associated house sites and auwai.

Both of the rock shelters found are located mauka of the project area. Site CS7 is a small dry overhang used today by marijuana growers. It does contain floor deposits but no sign of cultural material was observed. Site CS8 rock shelter appears to be a major landmark in the upper portion of the valley. It has an excellent overlook view down valley and is high enough to be protected from river flooding and the overhand is permanently dry. Bennett spent the night here in 1928 or 1929 and today it is well supplied marijuana growers camp. This site must have been used in prehistoric times and the floor deposits probably contain stratified cultural deposits with datable organic materials. A chronological framework for Hawaiian use of upper Hanalei Valley would begin with excavations at this site. However, the locality would not be impacted by the proposed hydroelectric project and negotiating with the current users of the shelter would be delicate.

The historic house sites CS1, CS3 and a feature of CS4 all appear to correlate to locations of houses on the 1916 U.S.G.S. map (Figure C-10a). Although in some cases house foundations were not visible (they were probably elevated wooden frame structures), bottles scattered about

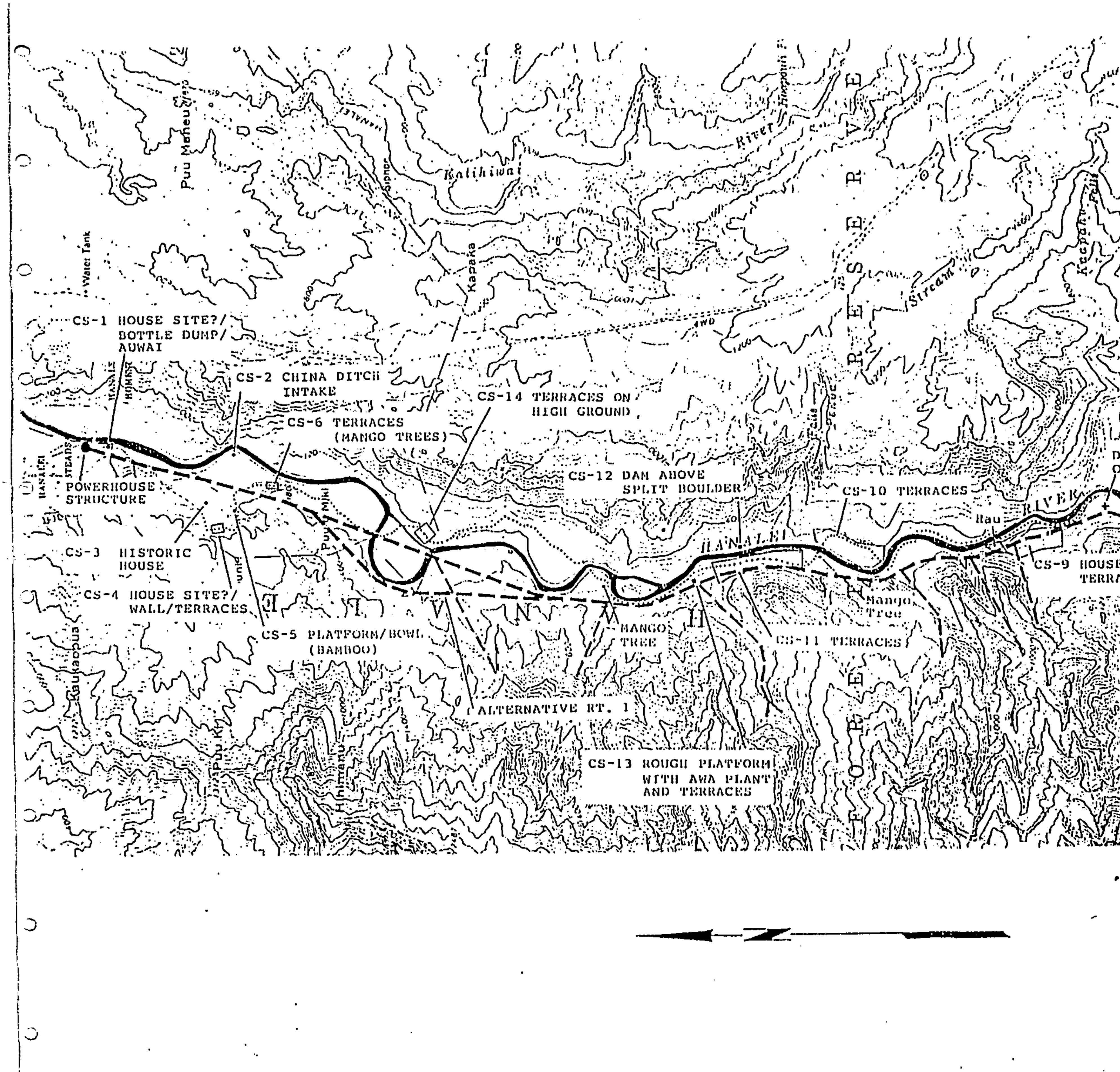
TABLE C-10

SUMMARY TABLE, UPPER HANALEI VALLEY

Site No.	Location	Description	Comments
CS1	West side of River near proposed power house	Historic house site and abandoned auwai	Correlates to house location on 1916 map. Auwai may be former "China Ditch"
CS2	West side of River	China Ditch intake	Supplies water to present Hanalei taro fields on west side of River
CS3	West side of River near present trail	Historic house site	Correlates to house location on 1916 map
CS4	West side of River	Historic house site, wall and terraces, and abandoned auwai	Housesite correlates to location on 1916 map. Wall and terraces probably prehistoric. Could be part of Bennett's site, 141.
CS5	West side of River by trail	Platform, with bowl carved in rock by trail	Possibly prehistoric site. Terraces could occur nearby
CS6	West side of river by trail	Terraces	Probably prehistoric
CS7	East side of River above Kaapoko Stream	Small rock shelter	May contain buried cultural material; prehistoric
CS8	East side of River above Kaapoko Stream	Rock shelter with good overlook down valley	Contains floor deposits; probably prehistoric; visited by Bennett

TABLE C-10 (cont.)

Site No.	Location	Description	Comments
CS9	West side of River below Kaapahu Stream	Housesite and terraces	Probably prehistoric; terraces extend up-slope, probably more extensive than observed; terraces parallel to River
CS10	East side of River above Pekoa Stream	Terraces - at least eleven terraced field levels	Prehistoric; terracing probably covers entire point bar. Terraces perpendicular to River.
CS11	West side of River opposite Pekoa Stream	Terraces - at least six levels	Prehistoric; terraces perpendicular to River; probably cover entire point bar.
CS12	East side of River	Dam wall above large split boulder	Dam is for water control; terraced fields probably associated. Split rock similar to Bennett's site 143.
CS13	East side of River by trail	Rough platform; awa plants	Prehistoric; could be house site or water control; terraces to north are perpen-dicular to River
CS14	West side of River by trail	Formal terraces on high ground	Prehistoric; could be dry land terraces (unirrigated)



Project Area Showing Archaeological Site Locations and Proposed Pipeline Route.

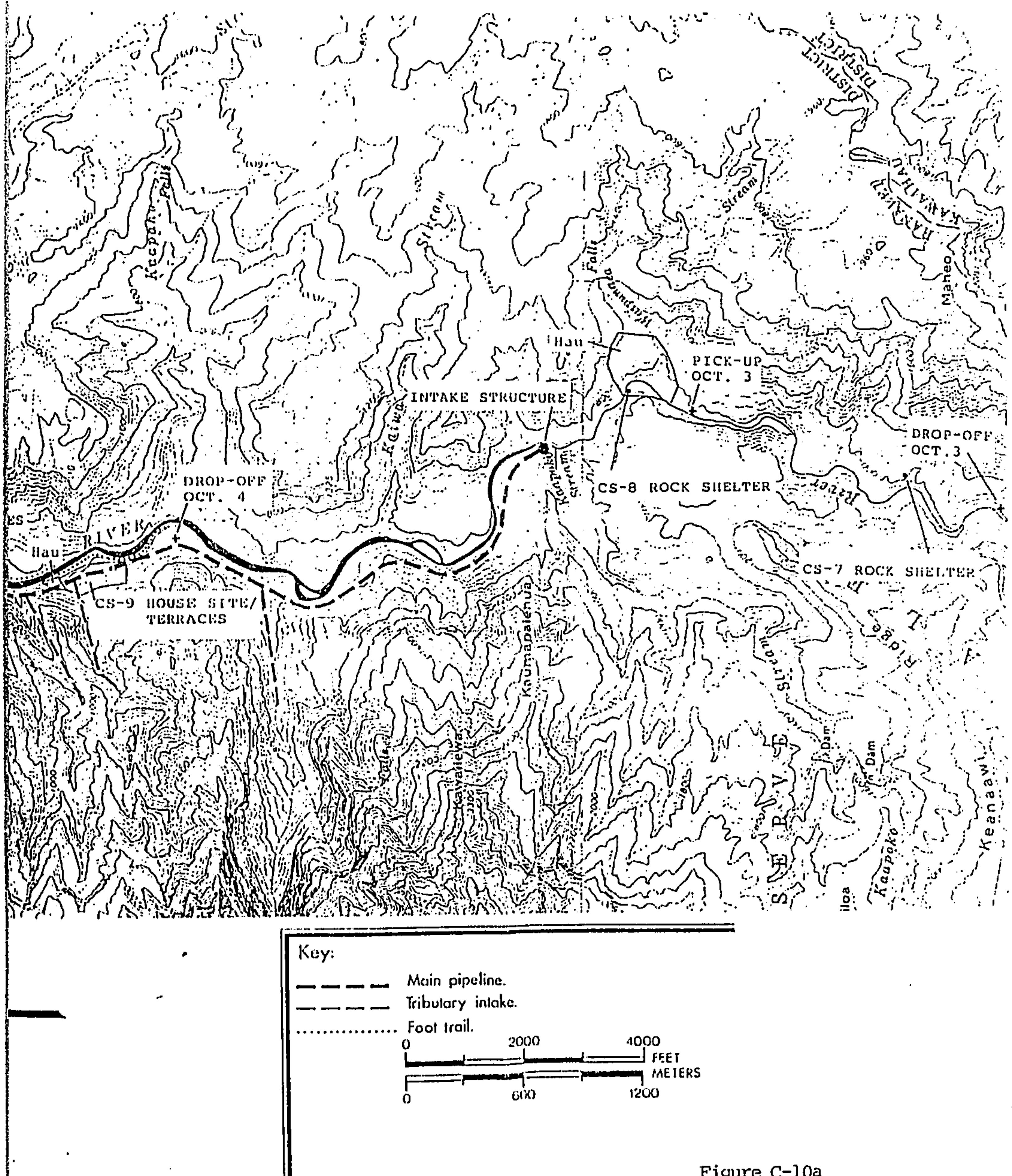

DISTRICT
KAWAIHAU
Stream
Maheo
Kaapoka Falls
Kaiwa Stream
Hau
PICK-UP
OCT. 3
INTAKE STRUCTURE
DROP-OFF
OCT. 3
CS-8 ROCK SHELTER
DROP-OFF
OCT. 4
RIVER
Hau
CS-7 ROCK SHELTER
CS-9 HOUSE SITE/
TERRACES
Ridge
Kaumanalehua
Stream
Kaapoko
Keanaawi
Key:
Main pipeline.
Tributary intake.
Foot trail.
0
2000
4000
FEET
METERS
0
600
1200

Figure C-10a

indicate use in the 1920's. It is probable although not certain that the economy of this settlement was supported by wetland irrigation and that terraces in this lower portion of the project area were used continuously from prehistoric times through the 1920's. These sites are of archaeological value in their potential for dating and characterizing historic use of the area and for documenting what appears to be progressive historic abandonment of the Valley. However, much of this information could be obtained effectively through informant interviews and historical search as a complement to archaeological methods. Of these 3 historic sites only CS1 is close to the proposed pipeline, although it is possible that terraces associated with all these sites could be impacted.

Site CS2, the present intake for the China Ditch which now supplies irrigation water to Hanalei taro fields is a modern feature and technically not a historic site. However, the ditch itself, or portions of it, was probably in use for many centuries. The abandoned auwai located at CS1 and near CS4 may be former routes or tributaries of the same ditch network.

Terraced agricultural complexes, some with house sites, include CS4, CS5, CS6, CS9, CS10, CS11, CS12, CS13 and CS14. These site areas as a group, particularly those in the upper portion of the valley, show evidence of extensive wetland cultivation almost certainly of the late prehistoric period. These sites are significant in the context of ancient Hawaiian social evolution and economic adaptation. Earle (1978:163) in his study of Halele'an taro cultivation and social organization argues that irrigated lands were under-utilized in the main portions of the valley and never extended into the less accessible, narrower parts of the valley and that dry land terracing on the slopes was not generally practiced. However, Bennett (1931:36) found terraces far back in Wainihi Valley even where it constricts and steepens (see also Handy and Handy 1972:419-420). Schilt documents dry land terracing on the slopes of Hanalei Valley (Schilt 1980:66). (See also Cordy 1974 for Lumahai Valley.) The significance of all this is that the expansion of late prehistoric agricultural land use in Hawaii is a measure of response to population pressure and political and social consolidation. The present reconnaissance survey confirms the presence of irrigated and possibly dry land agriculture into the remote lands of upper Hanalei Valley and once again confirms that the value of potentially productive lands to prehistoric Hawaiians and their ingenuity in developing them should not be underestimated.

Water availability was probably never a constraining factor in the Valley but flooding was a constant possibility. In all the terrace systems observed, the source of water was probably a tributary stream because these sources would be easier to channel to the higher parts of the point bars and more easily controlled in time of flood. Tributary streams that were potential water sources are easily discerned at CS9, 10, 11, 12, and 13. Site CS14 was the only area where terraces were observed on high ground and may be the single example of dry land agriculture located in this reconnaissance.

Given the obvious constraints of this reconnaissance — the most important being the dense vegetation — it was not possible to define the upslope limits of these terraced site areas or the exact location and complexity of the auwai systems that watered them. It is almost certain that some site areas present even adjacent to the river were not located in this reconnaissance. The survey gap from the intake structure to the October 4 drop-off when it is surveyed will probably add more sites to this inventory, particularly if Ka'apoko is Bennett's ka'apoku site area as the similarity in place names would seem to indicate.

Recreational and Aesthetic Resources. The Hanalei River area is recreationally significant for the island of Kauai. The Hanalei River Valley provides hunting and fishing opportunities as well as hiking opportunities. Hunting trails traverse the entire length of the Hanalei Valley up to the cross-basin diversion to South Fork of the Wailua. The Upper Hanalei River, however, is rated as strenuous hiking but is available for hikers and hunters. Hanalei River is one of the few streams which support an ethnic (goby) fishery. For example, during one freshet day (August 14, 1986), the 'o'opu-nakea (Awaous stamineus) were on spawning migration. At eleven in the morning of the next day, Dr. Timbol counted 49 persons pole fishing for the goby along the river banks in the vicinity of Hanalei bridge. Gill nets set to harvest the spawners numbered six: three by the rice mill, two by the Hanalei bridge and one just upstream of the Dolphin resturant. One group of 15 pole fishers caught 11 spawners in 10 minutes.

The river is one of seven streams on Kauai in the Nationwide Rivers Inventory, a listing of the Nations significant relatively natrual and free-flowing streams (The National Park Service 1982). It is described as "extremely photogenic".

KAUAI ELECTRIC UTILITY SYSTEM

A Brief History. Kauai Electric's history goes back more than three quarters of a century. Initially, an electric company was organized for the purpose of constructing a 2,400 kW hydroelectric plant for McBryde Sugar Company. The site chosen for the hydro plant was the Wainiha River.

Construction was a major undertaking for 1905 - not only involving the construction of the hydro plant, penstocks and transformer station, but also the laying of a 34-mile long power line over some of the island's most rugged terrain. Power was first supplied on August 4, 1906. The power company shortly thereafter became a subsidiary of McBryde Sugar Company.

By 1929 McBryde was distributing power for domestic use on the southern, western and northern sections of the island. Power to the central and eastern sections was provided by Lihue Plantation Company through its subsidiary, Waiahi Electric Company.

Early in the fifties these subsidiaries were merged into Kauai Electric Company. Kauai Electric Continued to serve a predominently agricultural economy. Kauai's visitor industry began to grow about this time and with it the island's economy. As a result, additional power was needed. The owners of Kauai Electric became hard-pressed to provide the capital for the badly needed generation, transmission and distribution facilities. As a result, they elected to sell Kauai Electric. In mid-1968 the owner negotiated to sell to Citizens Utilities Company. Kauai Electric became a part of Citizens in January, 1969 labeling itself Kauai Electric Division (KED).

To supply the power needs arising from the economic growth of the island, Citizens has invested more than 70 million during the past 16 years - enabling KED to progress from a simple distribution system to a modern full-service utility.

System Features. All the principal KED generation units are petroleum-based fueled plants. Internal combustion diesel units and gas turbine units utilize Number 2 diesel fuel and the steam unit utilizes Number 6 Bunker C fuel oil. There are no nuclear, coal or hydropower plants operated by KED. A general map of the system is shown on Figure C-11.

The transmission lines parallel the road transportation system except for the cross-island connection between Wainiha and Port Allen. The principal transmission lines are rated at 57.1 kv; secondary lines are at 12.47 kv, 11.5 kv, 6.9 kv and 4.16 kv. The major 57.1 kv lines are under lease or ownership by KED.

The island's electrical generation and consumption are restricted to Kauai; electrical inter-ites between the islands do not exist.

Power Purchases. In addition to the Kauai Electric Division owned and operated power plant and system features, KED maintains separate agreements with the four island sugar plantations for purchased capacity

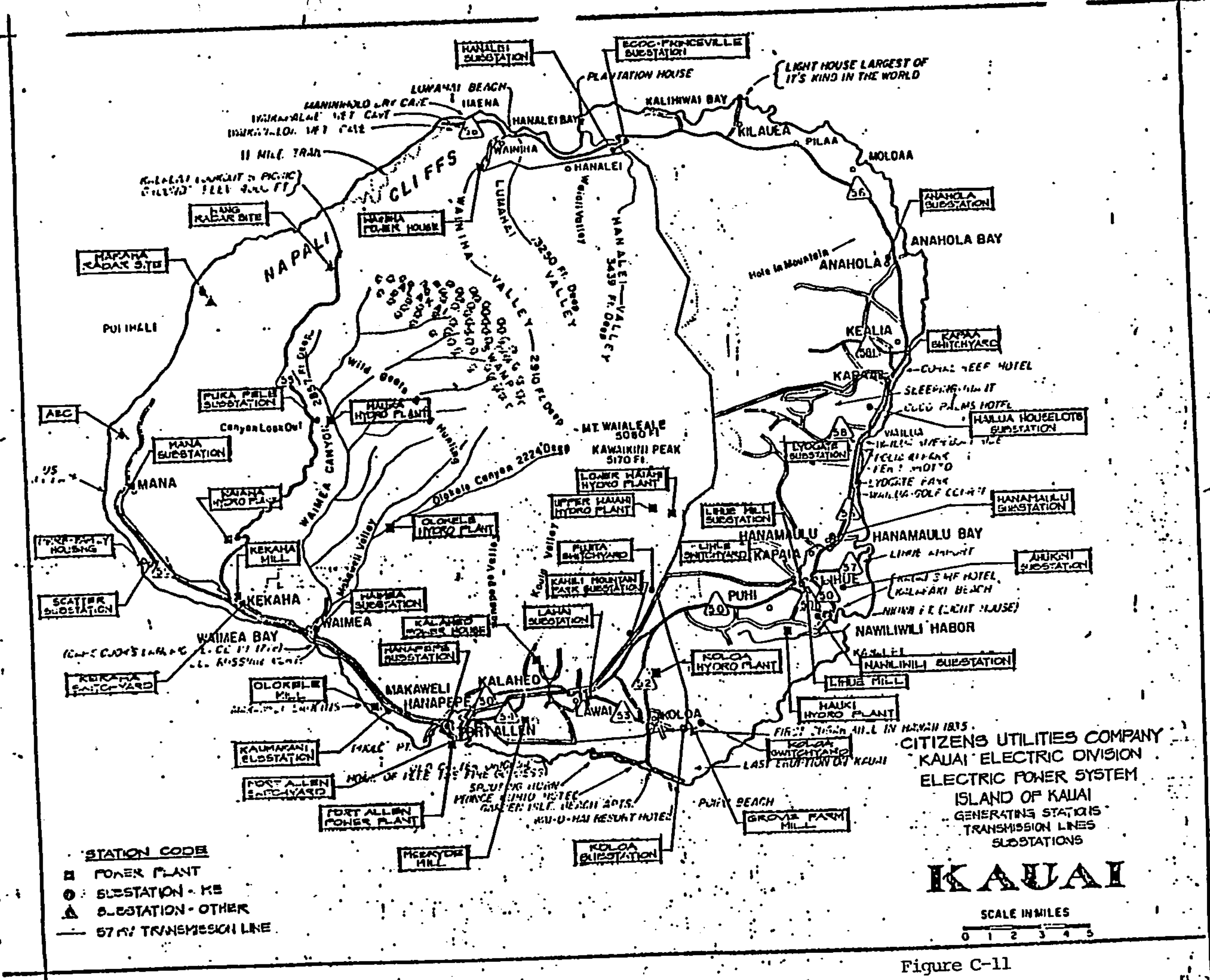

CITIZENS UTILITIES COMPANY
KAUAI ELECTRIC DIVISION
ELECTRIC POWER SYSTEM
ISLAND OF KAUAI
GENERATING STATIONS
TRANSMISSION LINES
SUBSTATIONS
KAUAI
SCALE IN MILES
0 1 2 3 4 5
STATION CODE
POWER PLANT
SUBSTATION - KE
SUBSTATION - OTHER
57 KV TRANSMISSION LINE
HANALEI SUBSTATION
PLANTATION HOUSE
LIGHT HOUSE LARGEST OF IT'S KIND IN THE WORLD
KALIHIWAI BAY
KILAUEA
PILAA
MOLOAA
ANAHOLA SUBSTATION
ANAHOLA BAY
ANAHOLA
Hole in Mountain
KEALIA
KAPAA SWITCHYARD
KAPAA
HAILUA HOUSELOTS SUBSTATION
HANAMAULU SUBSTATION
HANAMAULU BAY
HANAMAULU
KAPAIA
LIHUE
AHUKINI SUBSTATION
PUHI
NAWILIWILI HABOR
NAHLIWILI SUBSTATION
LIHUE MILL
HAUKI HYDRO PLANT
KOLOA SWITCHYARD
LAST ERUPTION ON KAUAI
GROVE FARM MILL
KOLOA SUBSTATION
KOLOA
KOLOA HYDRO PLANT
LAWAI
LAWAI SUBSTATION
KALAHEO
KALAHEO POWER HOUSE
HANAPEPE SUBSTATION
HANAPEPE
MAKAWELI
PORT ALLEN
FORT ALLEN POWER PLANT
FORT ALLEN SWITCHYARD
KAUMAKANI SUBSTATION
OLOKELE MILL
MCBRYDE MILL
WAIMEA
WAIMEA BAY
WAIMEA SUBSTATION
KEKAHA
KEKAHA MILL
KEKAHA SWITCHYARD
SCATTER SUBSTATION
MANA
MANA SUBSTATION
AEC
PUI IHALI
NAPALI
CLIFFS
11 MILE TRAIL
LUMAHAI BEACH
HAENA
HANALEI BAY
HANALEI
WAINIHA
WAINIHA POWER HOUSE
WAINIHA VALLEY
LUMAHAI
3250 Ft. Deep VALLEY
HANALEI VALLEY 3439 Ft. Deep
2910 Ft. Deep
MT. WAIALEALE 5080 Ft.
KAWAIKINI PEAK 5170 Ft.
LOWER WAIAHI HYDRO PLANT
UPPER WAIAHI HYDRO PLANT
LIHUE MILL SUBSTATION
LIHUE SWITCHYARD
PUUTA SWITCHYARD
KAHILI MOUNTAIN PARK SUBSTATION
OLOKELE HYDRO PLANT
WAIAWA HYDRO PLANT
WAIMEA CANYON 2857 Ft. Deep
Canyon Look Out
PUKA PELE SUBSTATION
KOKEE
Olokele Canyon 2224 Deep
Makaweli Valley
Wild Goats
Hunting
SWAMP
KAUAI HYDRO PLANT
Waioli Valley
Koula Valley
Hanapepe Valley
NAWILIWILI SUBSTATION
POIPU BEACH
FIRST SUGAR MILL IN HAWAII 1835
KOLOA HYDRO PLANT
KALALAU LOOKOUT & PICNIC
Figure C-11

FIGURE C-11

and energy. The four sugar plantations (Lihue, McBryde, Kekaha, and Okokele) use a combination of hydroelectric diesel, and bagasse-steam operations. As of 1985, approximately 40 percent of the industrial energy output or 98.7 million kwh was transferred to KED by these entities. Since 1969 the proportion of purchased energy has decreased from approximately 50 percent to 12.7 percent in 1980. From 1969 to 1976, KED maintained agreements for purchasable capacity; 1977 to 1980 required no purchasable capacity (except for emergencies).

Lihue Plantation. Pursuant to the agreement which went into effect early in 1981, Lihue provides 12 mw of firm dispatchable power under three price mechanisms covering 48 weeks of the year, with the remaining four weeks allotted for overhaul of the plant. Lihue must notify Kauai Electric before the harvest begins as to the length of the year's cane-grinding season which must be a minimum of 37 weeks. During this grinding season, Lihue generates power by burning bagasse, and Kauai Electric guarantees the purchase of 55.6 million kilowatt hours of this bagasse-based power, the price of which is based on the purchase price for fuel oil.

Kauai Electric may ask for more power than the 55.6 million kwh annual rate during the grinding season, and a second rate applies which is higher, as the assumption is that Lihue would have to burn oil to generate this extra power. From the end of the grinding season through the 48th week, a third rate applies when Lihue presumably must burn oil to produce power as all of its bagasse would have been used during the grinding season.

During this 48-week period, Kauai Electric has the right to buy up 96.8 million kwh of power. In addition to this three-tiered price mechanism, Lihue can offer Kauai Electric more power at a lower rate when it has extra bagasse to burn. Kauai Electric may accept it and pay the rate for surplus power. Lihue has supplied between 70 to 75 million kwh during three of its first four full years of operation.

Others. Kauai Electric also purchases power from Kekaha Sugar Company, Olokele Sugar Company and McBryde Sugar Company. It has new contracts with the suppliers calling for the surplus rate which moves with the price of oil. Kekaha supplies from 80 to 100 million kwh a year, Olokele about 800,000 kwh and McBryde 16 to 18 million kwh.

The volume supplied by the four plantations since 1981 has averaged approximately 40 percent of Kauai Electric's total output.

Installed Capacity and Energy Production. All energy generation made by KED is located at Port Allen. The KED system includes a mix of diesel, oil-fired steam, and gas turbine units. The bulk of the capacity is provided by the gas turbine units. A summary of the generation facilities for Kauai County including privately operated plants are shown in Table C-12. The gas turbines are also operated in combined cycle with flue gases firing the waste heat boiler of the steam unit.

The mix of electrical generation by fuel type for the Island of Kauai is approximately 45% from fossil fuel, 40% from bagasse and 15%

TABLE C-12

COUNTY OF KAUAI - EXISTING ELECTRIC GENERATION FACILITIES (1981)

OWNERSHIP AND UNIT	OIL & GAS FIRED GENERATION: CAPACITY (MW) INSTALLED	ACTUAL[1]	LIFETIME (YR) ONLINE	EST. RETIRE	HYDRO & RENEWABLE GENERATION: CAPACITY (MW) INSTALLED	ACTUAL	LIFETIME (YR) ONLINE	EST. RETIRE
KAUAI ELECTRIC DIVISION								
Diesel 1	2.00	1.225	1964	1994				
Diesel 2	2.00	1.225	1964	1994				
Diesel 3	2.75	2.50	1968	1998				
Diesel 4	2.75	2.50	1968	1998				
Diesel 5	2.75	2.50	1968	1998				
Steam	10.00	9.70	1969	1999				
Gas Turbine 1 (Hitachi)	17.65	16.10	1972	2000+				
Gas Turbine 2 (JBE)	22.18	20.53	1977	2000+				
Subtotal	62.08	57.48			0	0		
McBRYDE SUGAR CO.								
Steam 1	7.75	7.75	1965	1995				
Steam 2	7.75	0	1965	1995				
Steam (Old Site)	2.50	0	1982	1982				
Wainiha 1					1.8	1.6	1928	—
Wainiha 2					1.5	1.5	1928	—
Kalaheo					1.0	0.2	1925	—
Waiumalu					0.3	0.0	1919	Retired
Subtotal	18.0	7.75			4.3	4.0		
KEKAHA SUGAR CO.								
Steam 1	1.0	1.0	1930	—				
Steam 2	2.5	2.5	1950	—				
Steam 3	2.5	2.5	1929	—				
Lower Waiawa					0.50	0.33	1907	—
Mauka					1.00	0.75	1954	1984
Subtotal	6.0	6.0			1.50	1.20		
LIHUE PLANTATION SUGAR CO.								
Steam 1	2.0	1.75	1949	—				
Steam 2	4.0	4.0	1957	1987				
Steam 3	4.0	4.0	1957	1987				
Hydro 1					0.8	0.8	1941	—
Hydro 2					0.5	0.5	1930	—
Bagasse 1					20.0	20.0[2]	1981	2000+
Subtotal	10.0	9.75			21.3	21.3		
OLOKELE SUGAR CO.								
Steam 1	2.0	2.0	1965	1995				
Steam 2	0.75	0	1941	—				
Diesel 1	0.45	0.45	1970	2000				
Diesel 2	0.45	0.45	1970	2000				
Honopapa					0.5	0.5	1930	—
Subtotal	3.65	2.90			0.5	0.5		
TOTAL	99.73	83.38			25.7	25.3		
TOTAL GENERATION (MW)								
Installed	(125.43)							
Actual	(110.78)							

1/ Actual capacity for KED units reflects KED estimates of baseload capacity (Feb. 1, 1982 letter to HAPA from KED)
2/ 12 MW firm capacity sold to KED 11 months out of the year (except January).

hydroelectric. Table C-13 summarizes the amount and type of electrical generation on Kauai for 1985. Figure C-14 graphically depicts the electrical generation by fuel type for Kauai County.

Distribution and Load Centers. The load or service areas are designated by judicial districts. The largest peak demand and total energy consumption are located in the Lihue District. On an island-wide basis, the non-farm residential is the largest user of power followed closely by the industrial sector.

The use of power varies with the respective locations on the island. In 1985, the breakdown of Kauai's largest power consumer's for the various uses are as follows:

Residential - Koloa - Poipu
Commercial - Lihue
Industrial - Lihue
Street Light - Lihue
Sugar - Kekaha - Waimea

Table C-15 summarizes the load distribution for the various rate classes.

Future Power and Energy Requirements. The annual rate of increase in the peak energy demand has decreased in recent years from a 9.5 percent in 1977 down to the current rate of approximately 3.5 percent per year. Since 1969, the demand has doubled from 19.6 mw to 44.9 mw in 1985.

TABLE C-13

PRIMARY ELECTRICAL PRODUCTION 1985

			TOTAL NON-FOSSIL
OLOKELE			
From: bagasse		6,806,000 kwh	
hydro		6,296,300 kwh	13,102,300 kwh
diesel		475,040 kwh	
Bought from K.E.	395,000 kwh		
Sold to K.E.	1,954,000 kwh		
McBRYDE			
From: bagasse		24,869,000 kwh	
hydro - Waihiha		27,468,000 kwh	
- Other		4,491,000 kwh	56,828,000 kwh
Bought from K.E.	77,344 kwh		
Sold to K.E.	16,511,119 kwh		
KEKAHA			
From: bagasse		22,182,500 kwh	
hydro		8,125,700 kwh	30,308,200 kwh
Bought from K.E.	1,050,076 kwh		
Sold to K.E.	8,523,445 kwh		
LIHUE PLANTATION			
From: bagasse		88,286,146 kwh	
fuel oil		11,478,494 kwh	
hydro		7,526,300 kwh	95,812,446 kwh
Bought from K.E.	67,200 kwh		
Sold to K.E.	72,976,800 kwh		

Total Produced by all sugar companies: 208,004,480 kwh

Small power produced (Wm. Hyde Rice Ranch) 4,845 kwh

KAUAI ELECTRIC

Produced from fuel oil	150,990,000 kwh
Purchased from Sugar Companies	98,743,000 kwh

Kauai's Electricity Produced From Non-Fossil Fuels

1978 = 33% 1981 = 58% 1983 = 58% 1985 = 55%
1980 = 38% 1982 = 64% 1984 = 51%

Total electricity produced from Non-Fossil fuel 196,055,791 kwh

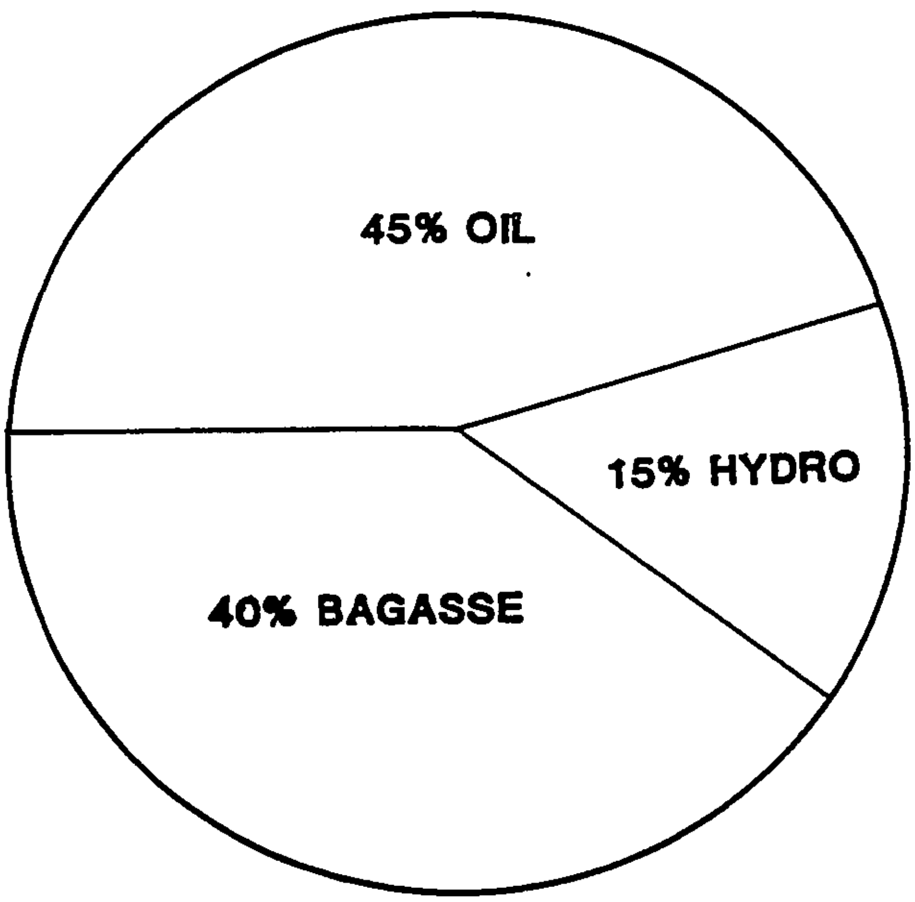
Total electricity produced from Petroleum 162,943,534 kwh

TOTAL KWH'S PRODUCED ON KAUAI 358,999,325 kwh

Data compiled by the Kauai Energy Extension Service
Office of Economic Development
4396 Rice Street
Lihue, HI 96766 Phone: 245-7305

ISLAND OF KAUAI

1985 ANNUAL TOTAL GENERATION – 248.8 MILLION KWH



SOURCE:
CITIZENS UTILITIES COMPANY
KAUAI ELECTRIC DIVISION
COMMUNICATION DATED –
JULY 26,1986

HANALEI HYDROELECTRIC PROJECT

ELECTRIC GENERATION BY FUEL TYPE

Figure C-14

TABLE C-15

KAUAI ELECTRIC DIVISION
LOAD DISTRIBUTION
ALL RATE CLASSES
REVIEW FOR YEAR END 1985
CENSUS TRACT CATEGORIES

Jul. 86

CT NO.	AREA	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	STREET LIGHT	SUGAR
4090	KEKAHA-WAIMEA	8.2%	6.4%	17.6%	11.5%	66.0%
4080	KAUMAKANI-HANAPEPE	5.0%	4.9%	0.0%	6.6%	24.9%
4070	ELEELE-KALAHEO	9.8%	6.0%	0.5%	11.2%	0.0%
4060	KOLOA-POIPU	15.7%	14.1%	14.7%	11.4%	4.9%
4050	LIHUE	11.3%	28.9%	32.1%	27.3%	4.2%
4040	PUHI-HANAMAULU	8.7%	9.8%	3.8%	4.6%	0.0%
4030	KAPAA	12.4%	12.6%	3.4%	16.3%	0.0%
4020	WAILUA-ANAHOLA	15.3%	8.1%	18.5%	6.6%	0.0%
4010	HANALEI	13.6%	9.2%	9.4%	4.5%	0.0%

According to officials of KED, the annual increase should remain steady at 3.5 percent compounded per year up to and including the year 2005.

Table C-16 summarizes the growth of the peak load requirements in the Kauai Electric System along with the projected future needs. These figures strongly indicate Kauai's need to expand its generating resources to meet its future energy requirements.

System Operational Characteristics. The Kauai Electric Division (KED) power system is operated, similar to normal electrical utilities, by a computer dispatch model. The computer assesses the operational costs of each component of the system and adjusts the power output from both the KED and purchased sources. As a result, depending on the load time of day, the capacity for each component may vary.

The critical month for operation appears not to be in the period of November through December during periods of peak demand but in the month of January. During this entire month the Lihue 12.0 MW bagasse plant is normally shutdown (in accordance to the contract) because of the cessation in sugar mill operations. The actual reserve capacity would decrease from 29.2 MW to 12.2 MW which is less than the capacity of the largest gas turbine unit (22.2 MW). The possibility of simultaneous shutdown of both the 12.0 MW Lihue plant and the 22.2 MW gas turbine No. 2, although remote, is of concern to KED officials. Hence, KED is required by the State Public Utilities Commission to maintain at least

TABLE C-16

KAUAI ELECTRIC DIVISION
CAPACITY EXPANSION PROGRAM

Jul-86

20 YEAR PEAK LOAD AND RESOURCE PROJECTION

LINE	YEAR	SYSTEM PEAK LOAD (MW)	SYSTEM OUTPUT (MWH)	GROWTH RATE (%)	LOAD FACTOR (%)	RESOURCES (MW)	RESERVE MARGIN (MW)	SALES (MWH)	GROWTH RATE (%)	LINE LOSSES (%)
====	====	=========	=======	=======	========	=========	=========	=========	========	=========
1	1972	26.1	137,049		59.94%	35.0	8.9	121,226		11.55%
2	1973	28.4	147,072	7.31%	59.12%	39.9	11.5	131,556	8.52%	10.55%
3	1974	27.2	149,460	1.62%	62.73%	39.9	12.7	135,587	3.08%	9.28%
4	1975	29.4	161,196	7.85%	62.59%	39.9	10.5	148,533	9.55%	7.86%
5	1976	31.7	167,638	4.00%	60.37%	39.9	8.2	155,834	4.92%	7.04%
6	1977	33.7	183,230	9.30%	62.07%	62.1	28.4	167,035	7.19%	8.84%
7	1978	35.9	201,011	9.70%	63.92%	62.1	26.2	179,299	7.34%	10.80%
8	1979	35.7	204,214	1.59%	65.30%	62.1	26.4	184,459	2.88%	9.67%
9	1980	37.3	211,126	3.38%	64.61%	62.1	24.8	188,798	2.35%	10.58%
10	1981	39.5	218,664	3.57%	63.19%	62.1	22.6	199,461	5.64%	8.79%
11	1982	39.6	216,999	-0.76%	62.55%	74.1	34.5	200,865	0.71%	7.44%
12	1983	40.3	224,834	3.61%	63.69%	74.1	33.8	209,712	4.40%	6.73%
13	1984	42.3	247,142	9.92%	66.70%	74.1	31.8	228,951	9.17%	7.36%
14	1985	44.9	248,842	0.69%	63.27%	74.1	29.2	231,008	0.90%	7.17%
15	1986	46.7	261,756	5.19%	64.00%	74.1	27.4	242,179	4.84%	7.48%
16	1987	49.8	279,449	6.76%	64.00%	74.1	24.3	258,269	6.64%	7.58%
17	1988	52.3	292,936	4.83%	64.00%	74.1	21.8	270,442	4.71%	7.68%
18	1989	54.7	306,424	4.60%	64.00%	82.4	27.7	282,587	4.49%	7.78%
19	1990	57.1	319,912	4.40%	64.00%	82.4	25.3	294,706	4.29%	7.88%
20	1991	59.5	333,400	4.22%	64.00%	82.4	22.9	306,798	4.10%	7.98%
21	1992	61.9	346,888	4.05%	64.00%	82.4	20.5	318,862	3.93%	8.08%
22	1993	64.3	360,376	3.89%	64.00%	90.6	26.3	330,900	3.78%	8.18%
23	1994	66.7	373,863	3.74%	64.00%	90.6	23.9	342,911	3.63%	8.28%
24	1995	69.1	387,351	3.61%	64.00%	90.6	21.5	354,895	3.49%	8.38%
25	1996	71.5	400,839	3.48%	64.00%	98.9	27.4	366,852	3.37%	8.48%
26	1997	73.9	414,327	3.36%	64.00%	98.9	24.9	378,782	3.25%	8.58%
27	1998	76.3	427,815	3.26%	64.00%	98.9	22.5	390,684	3.14%	8.68%
28	1999	78.7	441,303	3.15%	64.00%	98.9	20.1	402,560	3.04%	8.78%
29	2000	81.1	454,790	3.06%	64.00%	107.1	26.0	414,409	2.94%	8.88%
30	2001	83.5	468,278	2.97%	64.00%	107.1	23.6	426,231	2.85%	8.98%
31	2002	85.9	481,766	2.88%	64.00%	107.1	21.2	438,026	2.77%	9.08%
32	2003	88.3	495,254	2.80%	64.00%	115.4	27.0	449,794	2.69%	9.18%
33	2004	90.7	508,742	2.72%	64.00%	115.4	24.6	461,535	2.61%	9.28%
34	2005	93.1	522,230	2.65%	64.00%	115.4	22.2	473,249	2.54%	9.38%
35	GROWTH		3.51%					3.41%		
			=====					=====		

22.2 MW reserve capacity in the absence of additional utility or purchasable capacity.

The combined cycle operation of the gas turbine units is definitely an economic asset for KED. The exhaust gases of the gas turbine units are utilized to charge the waste heat boiler of the 10 MW unit. As a result, the combined cycle operation cannot be operative if both gas turbines and the stream units were on-line simultaneously.

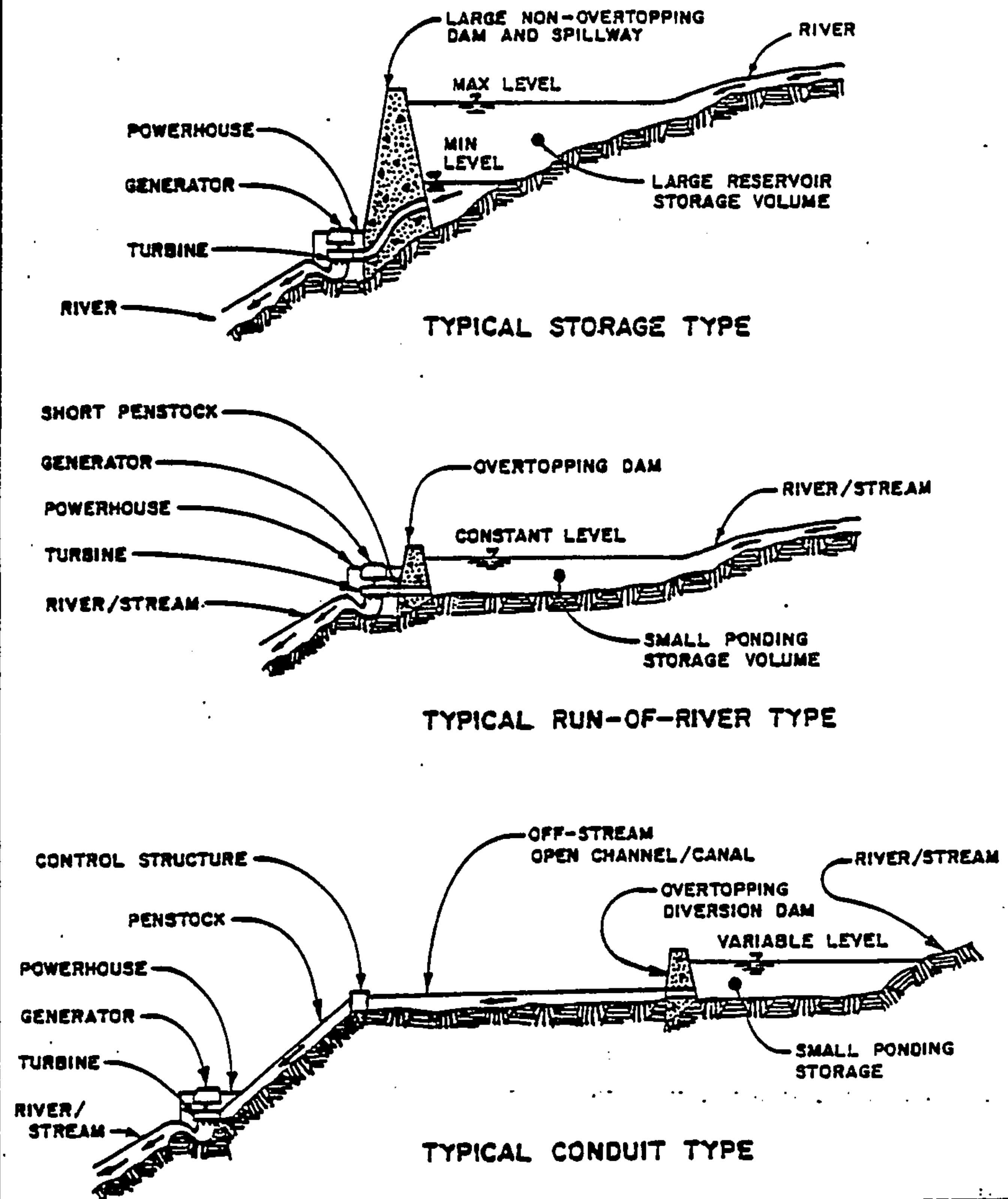
Hydropower Resources. The basic resources required for hydropower energy extraction are differences in elevation or head for the captured water, the rate of water flow, and the stability of flow over a time period (reflecting water storage and/or high perennial flows). The man-made resources required are a structure in the river to impound or capture the waters, a waterway to transport the waters, and electromechanical devices (turbines and generators) to convert the fall of flowing water ultimately to electrical energy. The potential hydropower resources are completely limited to the number and quality of sites on the island.

Existing Hydropower Developments. The island of Kauai, benefitting from topographic and hydrologic conditions, combined with historical development, produces more energy from hydropower sources than any of the Hawaiian Islands. The existing hydropower facilities were originally installed by the sugar industry in conjunction with their irrigation, pumping, or mill operations.

Conventional hydropower developments are in general categorized in terms of operational type, capacity and head requirements. The physical operational categories are storage, run-of-the-river, and conduit which are illustrated in Figure C-17. All of the existing hydropower facilities in the State of Hawaii and the island of Kauai (except for Alexander Reservoir) are considered conduit hydropower. A conduit system for hydropower development operates on instantaneous streamflow. The flows are diverted to a powerplant by means of a diversion system (dam, channel, canal, or tunnel) with limited pondage. The head to be developed depends on the difference in elevation between the penstock intake point

and the powerplant location. Power generated by a conduit system depends on streamflow fluctuations and may not be significant nor dependable during low flow periods.

In terms of capacity, hydropower developments are usally categorized in terms of large (greater than 30 MW), small (0.1 MW to 30 MW), and micro (less than 0.1 MW). All existing hydropower plants in Hawaii and any foreseeable development are small scale or smaller. Finally, in terms of head requirements hydropower formulation are usually categorized as normal head (greater than 20 meters or 65.8 feet), low head (5 meters to 20 meters), and ultra low head (less than 5 meters or 16.4 feet). All existing and any new facilities in Kauai would be normal head facilities. There are no large, high rate of flow rivers in Kauai which warrant significant low head facilities.



SOURCE: U.S.A. CORPS OF ENGINEERS
NATIONAL HYDROPOWER STUDY
ENVIRONMENTAL ASSESSMENT
(DRAFT, JULY 81)

WAILUA RIVER HAWAII

TYPICAL SCHEMATIC PROFILES OF CONVENTIONAL HYDROPOWER OPERATIONAL TYPES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

Figure C-17

A total of nine hydropower plants owned by the four sugar plantations and two businesses are currently operational on various stream and ditch locations on the island. The total capacity is 7.9 MW and the average annual energy produced is 46.9 million kwh. By far the most productive hydropower plant is the Wainiha plant operated by McBryde Sugar Company. The Wainiha plant produces approximately 27 million kwh of energy annually and essentially runs at full capacity throughout the year. Table C-18 summarizes all of the existing hydroelectric power facilities on Kauai along with their respective capacity and energy production.

Planned Hydropower Development. There have been a number of proposals for hydropower development or rehabilitation in Kauai since the last significant plant was constructed in 1954. The two principal areas on the island for potential new development are Waimea/Kokee area and the Wailua area. The Waimea/Kokee area is the location of the Kokee, Olokele, Kekaha, Kitano, and Puu Opae-Mana improvements. The Wailua area includes the Waialeale, Lihue and Wailua projects.

The once most ambitious projects were the Kokee Water and the Waialeale Hydropower projects. Each project involved substantial dam/reservoir and penstock construction and power plant on the order of 10 MW. However, neither has progressed beyond the feasibility stage and are not proceeding because of the high financial commitments required. The Kokee project had been deferred indefinitely principally because of the lack of Federal funding from the U.S. Department of Interior's Bureau of Reclamation. Activity for the Waialeale project has been suspended

TABLE C-18

EXISTING HYDROELECTRIC FACILITIES ON KAUAI

Plant Name	Stream	Installed Capacity (MW)	Annual Generation (Million/Kwlt)
Wainiha	Wainiha	3.6	26.6
Mauka	Waimea	1.0	5.0
Waiawa	Kahoana	0.5	1.9
Okokele	Makaweli	0.5	3.1
Kalaheo	Wahiawa	1.0	2.1
Lower Lihue	North Wailua	0.8	5.0
Upper Lihue	North Wailua	0.5	3.1
Namahana Farms	----	0.005	0.03
Kauai Papaya	----	0.014	0.10

because of infeasibility and the high cost of ($72 million, 1978 price level) construction.

The projects under current construction or investigation are much less massive in scope. Capacities vary between 1.5 to 8 MW and average annual energy varies between 7.6 to 29.5 million kwh.

At present, their are five (5) potential hydroelectric projects under feasibility studies for future development. The second Wainiha project and the Kitano project were granted CDUA permit approvals several years ago. These projects have not been constructed by the sugar plantations because of economic reasons. The probability of their being constructed is unknown.

The Wailua project was granted a CDUA permit in August 1986 and the developer is seeking the necessary permits for construction. The probability of this project being constructed is high. The Lumahai project is currently within the CDUA permit process. The probability of this project being constructed is unknown.

The proposed Hanalei project would be the largest, most productive hydroelectric facility on the Island of Kauai.

Table C-19 summarizes the potential hdyroelectric projects as listed by Kauai Electric Division. Figure C-20 shows the location of each of the projects in relationship to the KED system.

TABLE C-19

CITIZENS UTILITIES COMPANY
KAUAI ELECTRIC DIVISION

POTENTIAL HYDROELECTRIC PROJECTS
ESTIMATED COST, OUTPUT AND CAPACITY

Line No.	Map Ref.	Hydroelectric	$	Output (MWH)	Capacity (MW)
1	B	Wainiha	$14,000,000	23,000	3.6
2	E	Hanalei	$14,000,000	29,500	8.0
3	D	Lumahai	$11,000,000	23,700	6.0
4	A	Kitano	$ 3,500,000	7,600	1.5
5	C	Wailua	$10,500,000	16,000	6.6

Source:

Citizens Utilities Company, Kauai Electric Division
Communication dated July 26, 1986

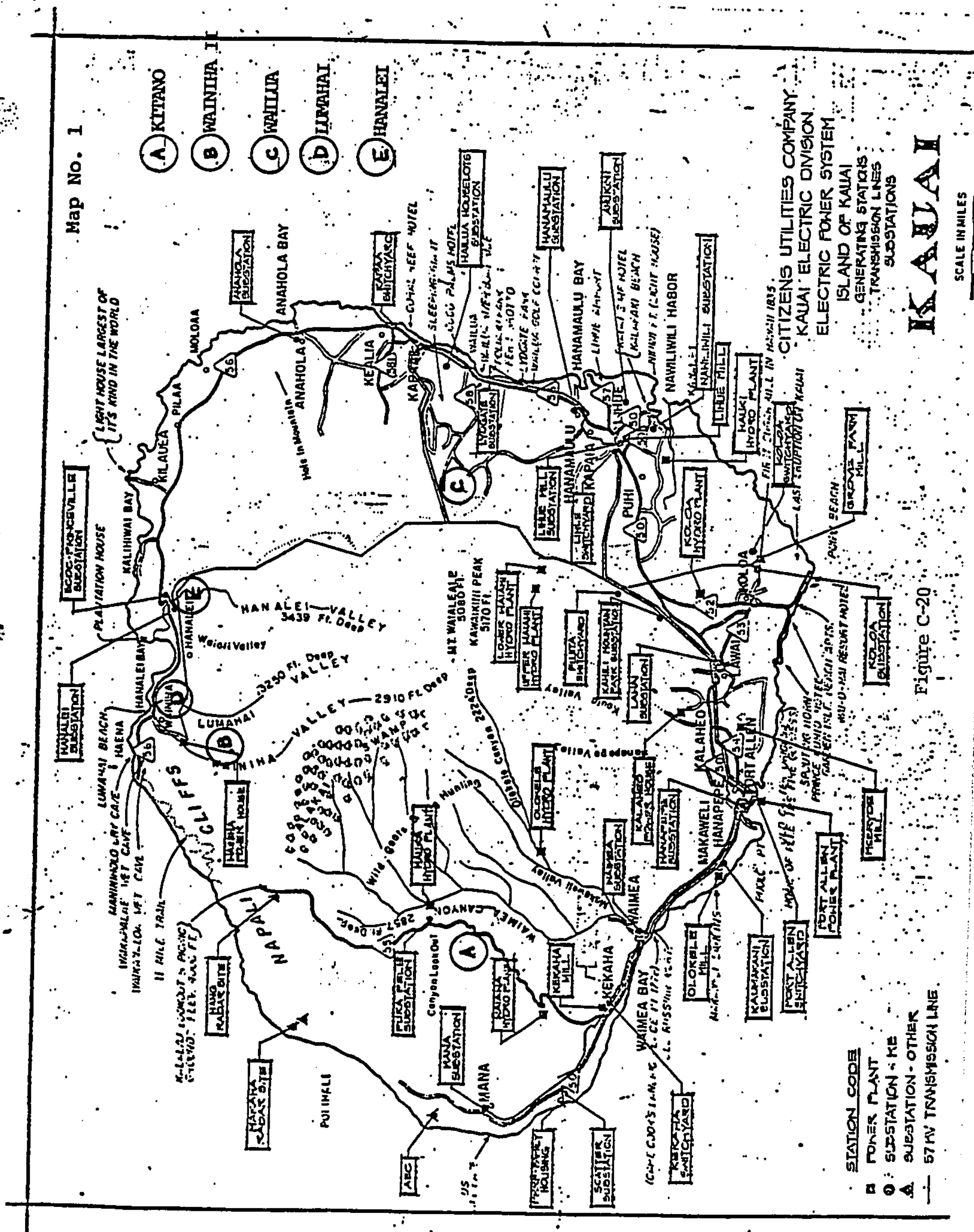

Map No. 1
A KITANO
B WAINIHA II
C WAILUA
D LUMAHAI
E HANALEI
CITIZENS UTILITIES COMPANY
KAUAI ELECTRIC DIVISION
ELECTRIC POWER SYSTEM
ISLAND OF KAUAI
KAUAI
SCALE IN MILES
STATION CODE
POWER PLANT
57 KV TRANSMISSION LINE
Figure C-20

figure C-20

D. THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREAS.

AFFECTS TO EXISTING LANDS

The proposed Hanalei project will directly affect lands owned exclusively by the State of Hawaii located on TMK 5:4:01. These lands are within "Conservation District" boundaries and are subzoned primarily as (R) resource use with a smaller amount as (P) protective use. The area is contained within the Halelea Forest Reserve.

Approximately 37.9 acres of these lands will be needed for construction and operation of the proposed project. A long term lease or easement will be sought for the acreage needed for the project. An annual rent will be assessed by the State of Hawaii for use of these lands which will be based upon fair market value.

The primary use of these lands is for recreational purposes. As there is no access for motorized vehicles in the project area, availability for use is limited to travel by foot. The terrain is very steep and rugged in the upper areas of the Hanalei River basin and only experienced hikers can safely utilize the area. There is no known information on the number of people who use this area each year for this purpose but it is not expected to be significant. These lands are also used for the hunting of feral pigs, goats and other animals.

There has been some speculation that the project area is illegally used for harvesting of marijuana plants. There is, however, no information available to document the extent of this use.

There are a number of uses of the land in the Hanalei River Valley both above and below the proposed diverted reaches of the project. Upstream from the proposed main diversion weir, is the Hanalei tunnel which is used to divert flows from the Hanalei Basin into the Wailua Basin for agricultural needs. Downstream of the project area, the lands have been used for many purposes including residential housing, taro farming, a National wildlife refuge, grazing for buffalo production and scenic beauty for tourism.

The proposed project will not affect uses of the land upstream from the diverted reaches of the proposed project.

The uses of the land adjacent to the diverted reaches of the project will be affected by the project. The principal and most significant impact will be the aesthetic losses due to a reduction of flows to the river channel. Further, the construction of new structures in an undeveloped area will also diminish the aesthetic beauty. A continuous minimum flow will bypass the main diversion weir and will remain in the river channel. In addition, only a portion of the river will be diverted, leaving the undiverted flows in the river channel. This will insure the protection of wildlife and aquatic resources in the area and will help to retain the aesthetic beauty of the river. Since no permanent access road is proposed in the upper reaches, increases in human use other than those related to project construction are not expected.

Uses of these lands for future agricultural purposes may be affected by the reduced amount of flow in the Hanalei River in the diverted reaches. However, the majority of these lands are between the existing taro fields and the powerhouse location. These lands would not be affected by the project.

Since no information exists as to harvesting of marijuana plants on lands adjacent to the diverted reaches of the project, affects to this use cannot be assessed.

The use of lands which are downstream from the project will not be directly affected by the project. However, the project will have some indirect short term affects which should be assessed. First, an increase in traffic along the residential roadway near the Hanalei Homestead will cause some inconvenience and vehicle noise during construction periods. This is expected to occur for approximately 14 months. Although inconvenient at times, this will not significantly affect the quality of human life in the area and will not affect land uses or values. The typically peacefull nature of the area will resume after construction has been completed.

The existing use of the lands for taro farming will not be affected by the project. All of the natural flows will be returned to the river channel at the powerhouse location. A 20% increase in sedimentation is expected during the first six month period during the initial disruption of the soils. However, these amounts will reduce to about 12% after one year and about 3% after two years. This should not cause any significant long term affects to agricultural uses downstream from the project.

As all of the flow will be returned to the river channel well upstream from the National wildlife refuge, the project will not affect this use of the land. These temporary increases in sedimentation will not significantly affect the use of the land for the wildlife refuge.

The majority of tourist related visits to the Hanalei Valley are to take photographs and enjoy its unique beauty from the scenic outlook. The view shed analysis prepared for the project, demonstrates that the major components of the project cannot be seen from this point as they are far upstream and out of view. Thus, the project will not significantly affect the use of lands in the area for tourism.

A minor amount of grazing occurs downstream from the project on cattle pastures a locally owned buffalo ranch. As all of the flows will be returned to the river, about six river miles upstream, no effects will be caused to this use by the project.

The Hanalei Estuary will not be significantly effected by the project since all of the flows are returned to the river channel about six river miles upstream from the mouth. A 20% increase in sedimentation will occur during the first six months of construction. This amount will reduce to about 12% after one year and 3% after two years. This amount will further decrease until revegetation is fully restored. This relatively minor amount of increase to sedimentation should not significantly effect the Hanalei Estuary or Hanalei Bay.

E. THE PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

WATER QUALITY

Under existing conditions the primary impact to water quality in the Hanalei River occurs from increases in sedimentation and turbidity from erosion caused by storms and freshets. Construction of the project would result in short-term impacts to water quality in the river. Activities including construction of access roads, excavation, and placement of fill material in the river will increase sedimentation of the river in the project area. Water turbidity will increase correspondingly, both in the project area and downstream. The introduction of potentially toxic substances such as petroleum products from construction machinery could be a hazard during construction.

In the steep mountain areas of the project, significant erosion and sedimentation problems can result from construction activities. Soil loss in the area can be caused by several factors: sloping land, high rainfall, erodible soils, and disturbance to the vegetative cover.

Earth moving activities will alter the soil by removing the protective vegetation, altering the topography, and changing site drainage and runoff patterns. The physical properties of the soil can also change.

Energy needed for erosion is supplied by the impact of rain and runoff. Raindrops break individual soil particles loose and surface runoff then carries the soil particles downslope. The impact of rain onto exposed soil for a period of from one to four minutes is known to have decreased infiltration to such an extent that up to 98 percent of the rainfall runs off.

Sedimentation can obstruct stream channels and reduce their hydraulic capacity which causes an increase in flood crests and flood damage. Fine grained sediments, such as clays, silts, and fine sands, may reduce the quantity and quality of the aquatic stream fauna. Additionally, the aesthetic attraction of an area and its waterways is impaired by erosion and sediment. If left uncontrolled sedimintation increases could lead to changes in the river channel, thus affecting farming and ranching operations below the project.

The construction of the diversion on the minor drainages will be done during the summer and it is not anticipated that cofferdams will be required. Construction and removal of the cofferdams will produce some fine sediment which will increase turbidity for a few days or until the first freshet. Should overtopping occur, turbidity will increase for the duration of high flow and until the cofferdams can be repaired, if necessary. A study of the "Effects of the Proposed Hanalei Development on Soil Loss" has been completed and is included as Appendix V to this report. The study indicates that under existing conditions the basin contributes 39.2 tons of soil in the form of erosion in a 6 month period. The study further indicates that clearing activities associated with construction of the project can contribute 4787 tons of soil loss if no control is exercised and best management practices are not followed. With the employment of the recommended techniques included in the report it is anticipated that the six month soil loss will be approximately

47.1 tons. This 20% increase is expected to be short lived and will decrease as vegetation reestablishes (See Table E-1).

Upon completion of the construction phases, sedimentation would diminish and eventually achieve pre-project conditions. Based upon the observations at existing run-of-the-river (new conduit) hydropower plants on Kauai, (Wainiha), no long-term effects such as thermal stress from power plant effluent are anticipated.

AIR QUALITY

Existing air quality within the project area is generally good and usually free of pollutants. It is effectively removed from urban areas and industrial point sources such as sugar mills. Influence from these sources is negligible.

Temporary increases in dust and smoke levels will be caused by the construction activities and the possible burning of vegetation removed from the construction site. These impacts will be short-lived and are not considered significant.

AQUATIC BIOLOGICAL RESOURCES

Implimentation of the project could result in temporary degradation of productive habitat for native species below the project diversion due to increased sedimentation from construction activities. Displacement or destruction of aquatic fauna resulting from excavation, transport and

TABLE 1

ANNUAL SOIL LOSS SUMMARY
HANALEI HYDRO

Condition	R	K	LS	C	P	Reclamation Time Period (Yrs.)	Tons/ Acre/ in 6 Months	Disturbed Area (ac)	Six Month Total Soil Loss Tons
Existing	400	.142	6.44	.008	1.0	0.5	1.5	26.16	39.2
Post-clearing, no control	400	.142	6.44	1.0	1.0	0.5	183	26.16	4,787
Post-clearing, short term control (Mulching)	400	.142	6.44	.02	1.0	0.5	3.7	26.16	96.8
Post-clearing, long term control (Seeding)	400	.142	6.44	.01	1.0	0.5	1.8	26.16	47.1

placement of fill material in the water during construction of diversion and intake structures and outlet channel would be additional anticipated short-term effects. Measures which could be practicably employed to minimize construction related adverse effects on aquatic resources are as follows:

1. Construction in the water and along the channel walls would be scheduled during June-September, the months of least rainfall.

2. During construction of the diversion structure and conduit, allowance must be made to provide continuous streamflow downstream of the construction.

3. Dredged and excavated material should be removed from the stream channel and not be temporarily stockpiled in the water.

4. Movement of heavy construction equipment in the stream should be avoided or minimized.

5. A buffer of material vegetation will be left between the river and the penstock where possible.

Long-term impacts associated with the project include partial diversion of the stream causing reduction of flow below the diversion structure, alteration of the normal seasonal flow regimes, subsequent habitat reduction and population decline of aquatic resources inhabiting the affected reach between the diversion and the power plant outfall. Approximately 5.2 miles of stream would be affected by the diversion.

The diversion structure would be designed to allow the continuous discharge of a conservation flow. It is proposed that this flow will be established through studies conducted by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service and funded by the applicant. Streamflows of less than 10 cfs and greater than 238 cfs would also pass through the diversion structure. (The 238 cfs is comprised of a maximum diversion of 106 cfs at the project intake and 132 cfs from a combination of the side diversions.) The structure would also have the capability of allowing periodic passage of flows between 10 - 238 cfs when necessary to flush sediment accumulation from the lower stream course and to accomodate spawning requirements of the native fishery resources in the lower reaches of the Hanalei River.

The following discussion and recommendation are taken from the 1986 Timbol "Survey of Aquatic Macrofauna in Hanalei River, and The Potential Impact of Hydroelectric Development" included as Appendix I to this report.

Potential Impacts and Mitigation. A pristine Hawaiian stream is an aggregate of bubbling brooks that have not been physically and biologically changed by human intervention (Maciolek 1975, p.8). Each of these brooks is visualized to have a complement of native species. The latest statewide inventory of streams (Timbol and Maciolek 1978) showed that no such stream exists today. A few streams show some signs of pristinity and many students of Hawaiian environment believe that Hanalei River is one of these. The construction, maintenance and operation of a hydroelectric facility in Hanalei Valley will have several potential impacts on the river biota. For purposes of discussion they are divided into five groups:

1. Blockage of fish migration
2. Loss or degradation of habitat
3. Change in the amount and pattern of instream flow
4. Mortality and morbidity of fish passing through turbines
5. Degradation of water quality

1. <u>Blockage of Fish Migration</u>

The proposed diversion weir on the main channel as well as the several diversion weirs on the tributaries could become physical barriers to the upstream passage of eggs and larvae of other native animals (i.e. 'opae-kala'ole). No study has been made on the effects of diversion weirs on migratory native Hawaiian fishes, crustaceans and mollusks. Similar installations have reduced or eliminated migratory fish populations in many drainage basins on the U.S. mainland (Baxter 1977).

Mitigative measures include adequate water flow over the weirs at all times. How much flow is adequate has not been established although 12 cfs has been suggested for the flood plain channel (Wilson Okamoto and Associates 1979) and 36 cfs was suggested for the upper elevation main channel (Timbol and Heacock 1986). The applicant is currently negotiating with the Corps of Engineers and U.S. Fish and Wildlife Service to complete the I.F.I.M. studies that will be utilized in determining minimum bypass flows for the project. It is proposed that the studies will be completed by the agencies and funded by the applicant. These flows will then be incorporated into the CDUA permit specifying operational criteria for the project. In addition to adequate flow, it is suggested that the downstream face of the weir should be sloping (1:4 slope) and be covered with river rocks. This design can faciliate the upstream movement of post-larval 'o'opu and other organisms. Several forms of fish-passage structures to facilitate fish migration are discussed by Gloss and Wahl (1983).

2. Loss of Degradation of Habitat

The diversion of stream flow will result in the alteration of water level and flow regime in channels below the diversions and before the powerhouse where the diverted water is returned to the main channel. The lowering of water level will lead to a loss of fish and other macrofaunae habitat. This will diminish the biological "carrying capacity" of the river.

Periodic exposure of the channel margin may eliminate algae, aquatic macrophytes, and riparian vegetation (Kroger 1973). Loss of algae and other vegetative materials reduces the food supply for grazing insects and fish and eliminates cover for these animals.

There are no mitigative measures for loss or degradation of habitat except to maintain an adequate instream flow.

3. <u>Change in Amount and Pattern of Instream Flow</u>

Two types of diversion are present in Hawaii's streams. The first type is complete diversion of surface flow. This leads to a depletion of native fishes, crustaceans and mollusks upstream of the diversion. For example, four west Maui streams (Honokowai, Kahoma, Kauaula, and Waikapu) do not have any native migratory fishes, crustaceans and mollusks above their diversions (Timbol and Maciolek 1978, p.93, 95-97). The second type, partial diversion, results in simultaneous modification of environmental conditions such as reduction of instream flow, changes in flow velocity, composition of substratum, excessive sedimentation, and high turbidity among others. Table E-2 shows the impacts of the proposed diversion on flows historically available in the diverted ponds.

Reduction of flow could lead to fish being stranded in the dewatered stretches of stream channels. The impact of predators such as the Tahitian prawns on the economically desirable 'o'opu-nakea will have a greater impact when they are concentrated in pools. In addition, native gobies prefer strongly flowing water (Kinzie <u>et al</u> 1984).

Reduction in flow reduces the scouring capacity of the stream. The resulting instream flow may not be enough to flush the accumulated organic debris and suspended sediment coming from construction and maintenance activities. This will lead to turbid water, reduced visibility and clog gills (Lloyd, Rochester and Fahr 1984). If sedimentation is heavy it will cover the bottom with dense layer of mud which could smother bottom invertebrates.

TABLE E-2

IMPACT TO FLOWS IN HANALEI RIVER

River Mile	Present Condition Mean Annual Flow (cfs)	Project Condition Mean Annual Flow (cfs)	Mean Annual Flow Not Diverted (%)
11.1	70.1	16.8	24
11.0	72.6	19.2	26
10.7	75.2	21.8	29
10.5	80.8	27.5	34
10.3	96.8	33.2	34
9.9	114.9	38.1	33
9.5	116.4	39.6	34
9.4	141.1	49.0	35
9.1	143.4	51.2	36
9.1	151.1	52.7	35
8.9	157.1	55.2	35
8.6	166.6	57.4	34
8.2	168.6	59.5	35
8.1	184.5	64.5	35
7.9	198.0	67.9	34
7.6	208.4	71.5	34
7.1	215.5	78.6	36
6.8	220.3	83.4	38
6.7	223.5	86.6	39
5.9	234.1	97.2	41
5.6	244.7	107.8	44

The impact can be substantially reduced by maintaining adequate instream flow. The work of Kinzie et al (1984) should be consulted since it deals with the native fishes in Hawaiian streams. An earlier study (Department of Health 1977) suggested that diversion may be limited to allow 50% of the lowest instantaneous flow on record in summer, and 30% in winter and that a 10% lower limit should apply at all times. A scheme for U.S. mainland streams (Tenant 1976) suggested 10% of the average flow is a minimum instantaneous flow which will sustain short-term survival habitat for most acquatic forms; 30% will sustain good survival conditions for most aquatic life forms and general recreation; and 60% will provide an excellent and outstanding condition for most aquatic life forms during their primary periods of growth and for the majority of recreational users.

4. Mortality and Morbidity of Fish Passing Through Turbines

Fish and crustaceans can be entrained in penstocks and turbines can injure and kill them. Eggs and early larval stages are particularly vulnerable to entrainment (Boreman 1977). The U.S. Army Corps of Engineers (1960) determined that if the penstock contained air, salmon fingerlings become acclimated to increased pressure, and they may be killed when the water is released. In addition, entrained macrofauna are killed instantaneously as they hit turbine blades or sustain injuries from which they eventually succumb (Rochester, Lloyd and Farr 1984). Delayed mortality is due to stress, physiological deterioration and increased predation. Furthermore, since migratory species orientation is positively rheotactic, flow releases at the proposed power plant could result in the entrainment of migratory juveniles (Boreman 1977).

Although hydroelectric facilities have been in operation for decades (Wainiha hydroelectric since 1906), the effects of penstock entrainment and passage through turbines on any of the native organisms have not been studied.

Mitigative measures include fish screens installed at both the upstream diversion sites and the point of water re-entry into the mainstream below the hydropower plant turbines.

5. Degradation of Water Quality

Reduction in instream flow caused by diversion and removal of riparian vegetation could mean higher water temperatures. Operation of vehicles and machines during the construction phase could lead to petrochemical pollution.

The effects of elevated temperatures can be lethal, metabolic and behavioral. Lethal temperatures make up the range within which the animal will die. Hathaway (1978) studied the effects of elevated temperatures on 'o'opu-nakea and 'opae-kala'ole. He found that adult 'o'opu-nakea died in water temperatures between 37°C and 39°C and post larvae at 39°C. The adult 'opae-kala'ole died at 34°C and the post larvae at between 35°C and 36°C. Metabolic effects are "delayed effects" as in growth acceleration resulting in the inability to reach and/or pass a critical point in the animal's life cycle (Andrewartha and Birch 1954). Brown trout stopped growth above a certain temperature and this could be due to respiratory requirements (Fry 1957). Behavioral effects are the organism's response to the environment. A motile animal will leave an area when conditions become unfavorable and will not voluntarily remain in the area until conditions become lethal. This is supported by Timbol and Maciolek's (1978, p. 57-58) work on altered and unaltered streams. The streams with low water temperatures harbored more native species than streams with high water temperatures.

The other probable cause of water quality degradation is chemical pollution from materials and vehicles during construction, maintenance and operation of the proposed hydroelectric facility. Other chemicals likely to pollute the land or find their way into streams includes fuels, lubricants and paints.

Mitigative measures include proper timing and effective maintenance to ensure that other mitigative measures (e.g. fish ladders and instream flow control) are working properly. If mainenance is effective, future problems that may require extensive construction usually are identified early enough so that plans for appropriate mitigations can be made.

TERRESTRIAL BIOLOGICAL RESOURCES

Vegetation. A total of 161 vascular plant species were inventoried during this survey. Of these, 88 (55%) are introduced or exotic species; 60 (37%) are native; and 13 (8%) are of Polynesian introduction. Among the 60 native species, 27 are indigenous (i.e., occur in the Hawaiian Islands and elsewhere) and 33 are endemic (i.e., occur only in the Hawaiian Islands). The majority, some 75%, of the Pteridophytes (Ferns and Fern Allies) are native. Introduced species are the most abundant elements among the Flowering Plants (Monocotyledons and Dicotyledons). The vegetation around the proposed powerhouse and lower half of the project site is dominated by forests of introduced species. In the upper half of the project site, from Pekoa Falls to the intake site, 'ohi'a trees (Metrosideros collina ssp. polymorpha) and other native species become more common.

Past disturbances by human beings and grazing animals, as well as feral pigs, can be observed throughout the project site. On the lower half of the project area, old house sites, abandoned livestock fencing and pastures, and forestry plantings are frequently found. Areas scarred by fire may also be seen on the slopes above the homestead lands. Traces of former occupation or use by the early Hawaiians are evident throughout the entire project site. Plants cultivated by the Hawaiians such as taro (Colocasia esculenta), 'awa (Piper methysticum), mountain apple (Syzygium malaccense), ohe (Schizostachyum glaucifolium) and banana (Musa sp.) are not uncommon. Large flat areas along the river, now vegetated by a grass-fern association were probably used by the Hawaiians to grow taro.

The proposed project is not expected to have a major impact on the native vegetation. The proposed penstock route, diversion weirs, access road, powerhouse, and transmission line will impact largely vegetation dominated by introduced species. The native species found on the project site are found in similar environmental habitats throughout the wet valleys of the north coast area as well as the forests of the Wai'ale'ale plateau. None of these species is considered Threatened or Endangered by the Federal and State governments.

Removal of vegetation, however, will result in increased soil erosion and sedimentation. It is recommended that disturbance from construction be kept to a minimum whenever possible. All cuts and exposed areas, especially on slopes, should be revegetated as soon as possible. Plant species already on the project site, such as Hilo grass (Paspalum conjugatum), narrow-leaved carpetgrass (Axonopus affinis), palapalai (Microlepia strigosa), hairy sword fern (Nephrolepis multiflora), and Spanish clover (Desmodium canum) should be used.

Stream side vegetation should be monitored on the project site. Withdrawal of water from the river and tributary streams will reduce instream flow. Woody growth may invade the present streamside vegetation now composed principally of grass and herbaceous species. During periods of heavy rain, this narrower river channel may flood. The woody vegetation occurring along the river's former edge may also contribute debris to the flood waters. Appropriate measures to remove and control brush along parts of the river may then have to be implemented.

Threatened or Endangered Species. No officially listed, proposed, or candidate Threatened or Endangered plant species (U.S. Fish and Wildlife Service 1980) were found during the course of this survey.

The status of the two mamaki species (Pipturis helleri, Pipturis kauaiensis) found during this survey is considered "uncertain", i.e., insufficient information available to determine if endangered, by Fosberg and Herbst (1975). However, both species occur in the native forests on the Wai'ale'ale plateau and in the many deeply dissected valleys. Recently collected specimens can be found in herbarium collections. On the project site, the plants generally occur as scattered individuals. The plants are more numerous along the river above the project site.

Avifauna. The proposed project should have not effect on the two native shorebirds (Wandering Tattler and Pacific Golden Plover) found along the Hanalei River on March 1 and 2, 1986. They are also found along the Wainiha River despite its dams and power plant.

The chief concern about the proposed hydroelectric power project deals with its possible effects on the Hanalei National Wildlife Refuge at Hanalei. This refuge is classified as a "primary" habitat for most of the endangered Hawaiian waterbirds (Walker, et al., 1978; see, also, Byrd and Zeillemaker, in press). On May 1, 1986, Dr. A. J. Berger talked with Mr. Jim Krakowski, Wetlands Coordinator for the U.S. Fish and Wildlife Service, in Honolulu, about the current status of the birds at the Refuge. The Hawaiian Gallinule or 'Alae 'Ula (Gallinula chloropus sandvicensis) is the most common nesting bird in the Refuge. The first nest of the Hawaiian Coot or 'Alae Ke'Oke'o (Fulica americana alai) apparently was found on the Refuge during 1985. Only a few Hawaiian Stilts or Ae'o (Himantopus mexicanus knudseni) nest on the dikes separating the ponds; most of the stilts nest elsewhere on Kauai. Most Koloa spend much of the day feeding on the Refuge, and only a few nest at this low elevation. The first concern is that there might be a decrease in water flow to the refuge during construction and after the power plant is in operation. The second concern deals with the amount of sedimentation that might reach the Refuge, especially during construction. If these engineering problems can be solved or alleviated, Dr. Berger feels "there is no reason that the proposed project should have an adverse effect on any endemic Hawaiian bird." Walker (1984) reported that no waterbirds were seen along the "Lower Hanalei River". Project construction will not decrease water flow below the project either during construction or after the power plant is in operation. The powerhouse has intentionally been located upstream of the Refuge so as not to interfere with the water flow in the Refuge. Waters reverted for project operation will be returned to their natural stream channel above the Wailua Refuge boundary. Increased sedimentation which occur as a result of project construction will be limited primarily to the construction season. By following the best recommended management practice, increases in sedimentation are expected to range approximately 20% greater than naturally occurring sedimentation loads (see "Effects of the Proposed Hanalei Development on Soils Loss" contained as an appendix to this report). Reseeding of all disturbed areas is also planned in conjunction with construction of the project. Revegetation of the disturbed areas should radically reduce the erosion associated with construction. As the vegetation matures, soil loss and erosion from any area of the project should reach approximately pre-project levels. Tom C. Telfer, Kauai District Wildlife Biologist for DLNR, Division of Forestry and Wildlife reports that the Townsend (Newell's) Shearwater a threatened species nests within the Hanalei River basin. There are also likely populations of the endangered Dark-rump Petrel and the extremely rare Band-rump Storm Petrel in the area (July 1986 letter Tom C. Telfer to Ralph E. Dachler, Kaui District Forestor).

Endangered Species

In consultations with Dr. Andrew J. Berger about the effects of the project on the Newell's Shearwater, Dark-rump Petrel, and rare Band-rumped Petrel, that even if the species were nesting in the area of construction and operation along the Hanalei River itself should have no servious adverse effect on the birds (July 28, 1986 letter to Clark M. Mower from Dr. Andrew J. Berger).

The endangered Hawaiian Duck (Koloa), the threatened Townsend Shearwater, and possibly other species could be impacted in a negative manner as a result of this project. This impact would be limited to temporary displacement and a minimal loss of potential habitat.

Mammals and Amphibians. Because there are no endemic amphibians or land reptiles in the Hawaiian Islands, all of those that are present are

alien or introduced species. None is an endangered species and none is pertinent to an environmental impact assessment. In fact, the bullfrog is known to be a predator on the downy young of the endangered waterbirds, and the neotropical toad is, because of the poison glands on its back, a cause of poisoning of dogs that bite the toad.

The Hawaiian bat (endangered) is the only endemic land mammal in the Hawaiian Islands. None were sited during the survey of the project area, however, they are known to be quite abundant on Kauai (Telfer 1986 Memo). There is no evidence that the bat occurs in the Hanalei River drainage system. Bats feed on insects at night; on the island of Hawaii they are common in towns. The construction of a dam and penstock should have no effect on the bat (see Tomich, 1969, 1974).

All of the remaining mammals found on the project adjacent to the project site are introduced species and all are serious pests to man, his activities and products, and/or to the native flora and fauna. The three species of rats prey on ground-nesting and even tree-nesting birds, and the mouse and the rats cause great damage to agriculture as well as to homes and industrial plants. And, as mentioned earlier, pigs cause great destruction of native forests. If it were possible to extreminate all of these alien mammals, it would be a great boon for the islands. There presence, therefore, is irrelevant to an environmental impact assessment.[1]

Public hunting of the feral pig occurs in the project area. Construction activities and the associated noise and disturbance will displace the wildlife naturally occurring in the area and could effect hunting success. Construction of an above ground penstock could also limit movement of

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[1] A.J. Berger, Tetrapod Vertebrates of the Lower Hanalei River, 1986.

pigs, hunters, and hunting dogs. Construction of an access road for construction equipment and materials into the area could also open up the area for increased travel. Construction plans for the project include: the provision for 50 foot crossings every 1,000 feet to allow for free movement of wildlife and hunters. The access road into the area will be closed to vehicular traffic following completion of project construction. However, the construction related acitivities will leave an improved trail system in the area which could lead to increased accessibility and hunter use of the area. If this expected increase occurs then corresponding decreases and hunters successes could be experienced as the naturally occurring population is completed.

CULTURAL AND HISTORICAL RESOURCES

A total of fourteen site areas were located in this reconnaissance survey. Summary information on these areas is presented in Section C of this report.

Generally there are three types of sites: 1) rock shelters, 2) historic house sites, and 3) agricultural terraces, some with associated house sites and auwai. These sites are described and shown on maps and text contained in Section C. The following Alpha numeric designation refer to the sites referenced in Section C.

Rock shelters CS7 and CS8 are outside the project and would not be impacted. CS10, 12 and 14 are on the east side of the river and would only be impacted by possible secondary activities such as roads, staging areas, etc. Site CS3, 4 and 5 are to the west of the pipeline but the terraces of CS4 could extend to the river bank. The terraces of Site CS6 would also probably by impacted. Sites CS9, 11 and 13 site areas are definitely in the patch of the proposed pipeline and would be directly impacted by the presently planned route of the pipe.

Because of the contraints of this reconnaissance (mostly dense vegetation), the boundaries of these site areas are not well defined. There could be other as yet undiscovered sites on other point bars which were not examined. These sites in some cases could extend at least for a short distance up tributary streams where site intakes are planned.

For these reasons, a more thorough survey is recommended for the exact route of the main pipeline as well as the tributary intakes. Taking into account our experiences in this reconnaissance, this survey should be undertaken after the pipeline corridor has been surveyed and at least partially cleared of vegetation.

At the completion of this survey it should be possible to accurately define site boundaries in relation to the exact pipeline route to find other as yet undiscovered sites. There are 4 major point bars along the pipeline route not covered in this reconnaissance that may contain archaeological sites.

On the basis of such a survey, mitigative action can be recommended such as adjusting the pipeline route or further documentation of sites if impact is unavoidable.

WETLANDS

No wetlands are located in the proposed project area. A band of vegetation composed mostly of various wetland species of grasses and ferns, as well as a number of herbaceous species, is found along the river at the water's edge. This area is subject to periodic inundation and the turbulent flood waters often sweep away some of the vegetation. The band of vegetation may be absent or very sparse where the river is narrow and runs swiftly. It is broadest and most dense where the river is wide and runs slowly.

In the lower portion of the project site -- the area below Pekoa Falls -- Californiagrass is the most abundant component of the streamside vegetation. Other species which are common in these Californiagrass dominated areas include large crabgrass, downy wood fern, Hilo grass, and hono-hono. Locally common are patches of Job's tears.

In the upper portions of the project site, Californiagrass is gradually replaced by Job's tears and neke, a native fern.

Scattered plants of kamole, puakamoli, drymaria, honeywort, taro, Glenwoodgrass, and pohekula are often encountered in the streamside vegetation.

A few small saplings and seedlings of the tree and shrub species from the surrounding forests are also encountered. Most of these plants, however, are swept away during periods of heavy rain.

The Hanalei Wildlife Refuge is located below the project area. The powerhouse site has been moved upstream to eliminate potential conflicts with the refuge. The flows diverted for project operation will be returned to the river well above the refuge boundary. Construction activities will cause increased erosion and sedimentation in the river. These increases could have an effect on the riparian vegetation below the project. By following best construction practices this increase can be minimized. Any impacts will be temporary. It is expected that after the vegetation disturbed by construction activities has been pre-established sedimentation in the river will return to pre-project levels.

Concerns have been raised about possible effects of the project on the estuary and agricultural land located below the project. There is very little information available on water quality and in these areas. In order to more adequately assess the impacts of development in these areas the applicant has agreed to cooperate with the citizens and the agencies in a proposed one year base line study of the North Shore area. The baseline study should not preclude the concurrent processing of the CDUA permit for the Hanalei project.

PRIME AGRICULTURAL LANDS

The proposed project lies entirely within "Conservation District" lands of the Halalea Forest Reserve located in Hanalei District. The majority of the land is within Reserve (R) Subzone and a small portion of the project lies within Protective (P) Subzone. There are no prime agricultural lands within the project boundary. Hanalei Valley below the project contains numerous farms and cattle pastures as well as a commercial buffalo ranch. These areas are irrigated with flows from the Hanalei River. Flows diverted from the river for project operation will be returned to the river well above any existing irrigation diversions. Operation of the project will not effect flows available for use below the project. During construction the flows will bypass the area of construction and will be available below the project. During and immediately by following construction disturbed areas will contribute to increased erosion and increased sedimentation in the river. By following best construction practices this increased sedimentation can be controlled to approximately a 20% increase over a 6 month period.

As the vegetation reestablishes the effects of the erosion will decrease until they are expected to reach pre-project conditions. At the end of two years it is expected that erosion increases will be approximately 3% over pre-project conditions (see Effects of the Proposed Hanalei Development on Soils Loss, Corbin A. Bennion, 1987 contained in the appendix to this report).

The applicant has also agreed to allow flushing flows as determined by the agencies to bypass the project and provide the natural seasonal flushing of siltation from the river channel.

SOCIAL, ECONOMIC AND POPULATION

Urban and community impacts such as income distribution, employment distribution, population distribution and composition, the fiscal condition of the local government, and the quality of community life; (b) Life, health and safety; (c) Displacement including people, businesses, and farms; (d) Long term productivity involving renewable resources; and (e) Energy requirements and energy conservation both during construction and operation of facilities.

The social effects of the proposed project are mainly island-wide in nature. All of the project's components are physically located far from population centers, and in fact would displace no people, or individual businesses or farms. Construction activities will create a temporary inconvenience to people living in the Hanalei homestead area. No changes in existing income, employment or population distribution or composition are anticipated as a result of implementing the project. The quality of community life will be effected, but the nature of that quality is believed to be related to recreational activities and aesthetic perception more than any other factors. There are few life, health and safety considerations. The likelihood of dam failure with resultant flash floods is miniscule both because of the design of the diversion structure (designed up to the Probable Maximum Flood) and because of the comparatively small amount of water impounded behind the diversion structure.

The following table (Table E-3) depicts the changing population distribution on Kauai between 1970 and 1980 which saw unusually high growth of the census tracts comprising Hanalei and Wailua-Anahola (excluding (Kapaa). Even by the 1974 sample survey, these trends could

TABLE E-3
POPULATION DISTRIBUTION ON KAUAI ISLAND, 1970-1980

CENSUS TRACTS

Year	Total Kauai	401 Hanalei	402 Wailua Anahola	403 Kapaa	404 Puhi-Hanamulu	405 Lihue	406 Koloa-Poipu	407 Eleele-Kalaheo	408 Kaumakani-Hanapepe	409 Kekaha-Waimea
1970[1]	29,524	1,182	3,599	3,794	3,642	3,124	3,141	3,660	3,173	4,159
1974[2]	29,460	1,700	4,220	3,630	3,140	3,090	2,850	3,910	2,700	4,220
1980[1]	38,856	2,668	6,030	4,467	4,590	4,000	3,879	4,855	3,111	5,256

1 State Department of Planning and Economic Development. The State of Hawaii Data Book 1981, A Statistical Abstract. November 1981.

2 Anderson, Robert N. and others. Kauai Socioeconomic Profile. Department Paper 35. Honolulu; Center for Nonmetropolican Planning and Development, Cooperative Extension Service and Hawaii Agricultural Experiment Station, University of Hawaii, May 1975, Table 9.

be perceived. Table E-4 depicts these regional characteristics for the census of 1980. Census tract 401 encompasses the project area.

Although some temporary increases in employment and related economic factors will be realized during construction of the project, no significant or long term impacts to the existing social, economic and population factors in the area are expected. The project will provide a significant increase to the tax base in the Hanalei region.

Recreational and Aesthetic Resources. The Hanalei River area is recreationally significant for the island of Kauai. The Hanalei River Valley provides hunting and fishing opportunities as well as hiking opportunities. Hunting trails traverse the entire length of the Hanalei Valley up to the cross-basin diversion to the South Fork of the Wailua.

Construction of an above ground pipeline along the Hanalei River could impact on the movement of feral pigs, hunters and dogs in the area. The pipeline could also restrict hikers and fishermen in using the trails to access areas in the upper reaches of the Hanalei River area. The project has been planned to provide 50 foot wide crossings every 1,000 feet. This will allow for the movement of animals and men back and forth throughout the length of the penstock. Construction of the project will require access roads to provide for movement of equipment and materials into the project area. Following construction these trails will be reseeded and closed to vehicular access but would be available for pedestrian access to and from the area. This improved access could lead to an

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POPULATION CHARACTERISTICS BY CENSUS TRACTS
KAUAI 1980

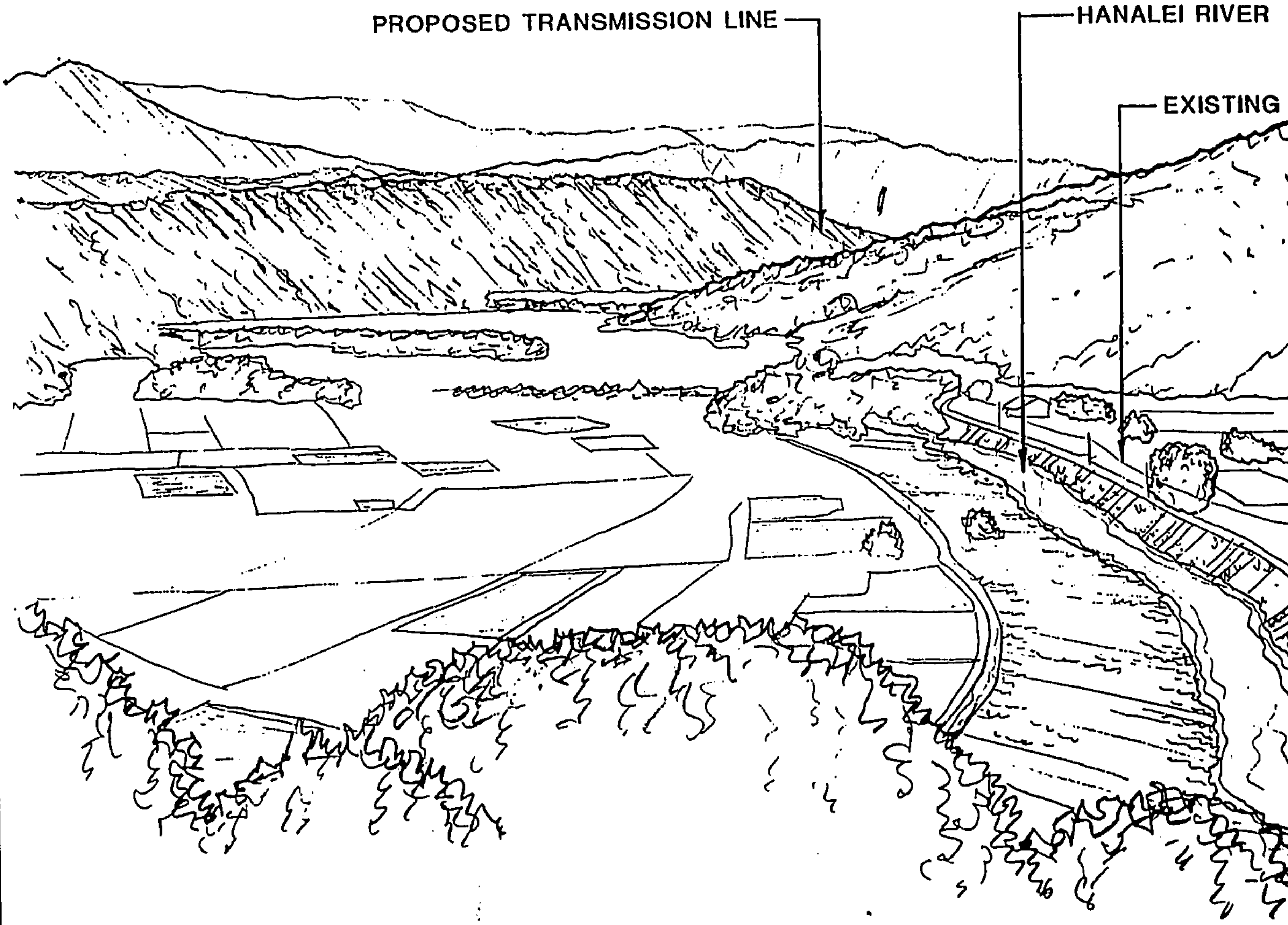
CENSUS TRACTS		Hanalei 401	Wailua/Anahola 402	Kapaa 403	Puhi/Hanamaulu 404	Lihue 405
HOUSEHOLDS		902	1,829	1,425	1,181	1,389
HOUSING UNITS (Including vacant, seasonal and migatory units) BY URBAN AND RURAL	Total	1,731	1,965	1,824	1,302	1,597
	Rural	1,731	1,965	-	466	-
YEAR-ROUND HOUSING UNITS BY OCCUPANCY STATUS	Total	1,468	1,955	1,821	1,302	1,597
	Occupied	902	1,829	1,425	1,181	1,389
	Vacant	566	126	396	121	208
OCCUPIED HOUSING UNITS BY TENURE	Total	902	1,829	1,425	1,181	1,389
	Renter Occupied	423	637	721	429	550
CONDOMINIUM HOUSING UNITS BY TENURE AND VACANCY STATUS	Total	467	16	320	79	213
	Renter Occupied	44	5	18	4	54
	Vacant for Sale Only	12	1	-	-	2
	Other Vacant	392	N/A	296	75	133
MEDIAN OCCUPIED HOUSING UNITS BY TENURE & PERSONS IN UNIT	Total	2.56	2.97	2.68	3.44	2.43
	Renter Occupied	-	N/A	N/A	N/A	N/A
PERSONS PER UNIT		2.94	3.27	3.08	3.83	3.84
MEDIAN SPECIFIED OWNER-OCCUPIED NONCONDOMINIUM HOUSING UNITS BY VALUE	Median Value	$ 105,100	$ 104,300	$ 85,600	$ 71,800	$ 101,200
MEDIAN CONTRACT RENT FOR SPECIFIED RENTER-OCCUPIED HOUSING UNITS PAYING CASH RENT	Median contract Rent	$ 371	$ 318	$ 251	$ 155	$ 227

Source: 1985 Kauai Statistical Review. Office of Economic Development.

Table E-4

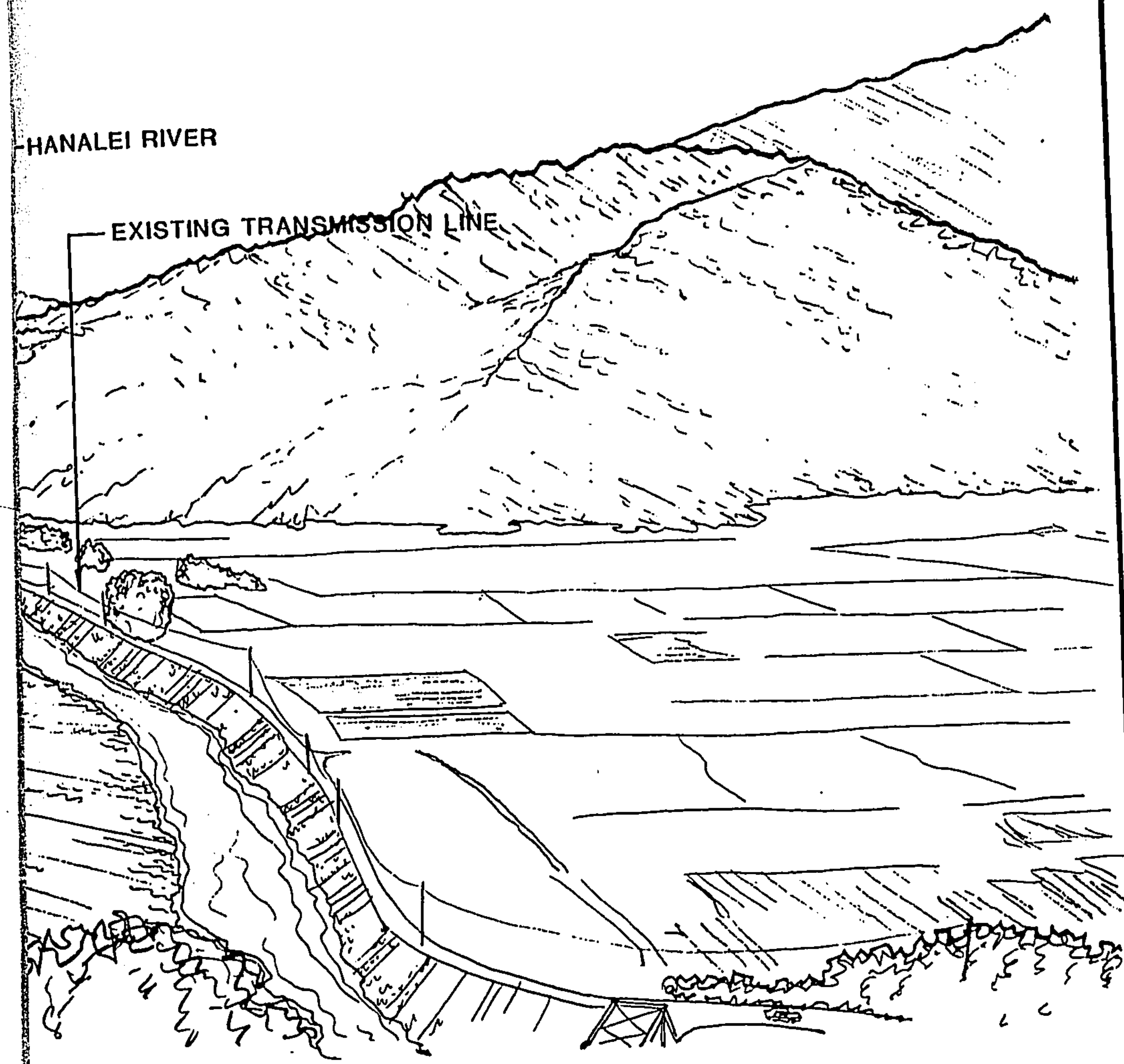
increased useage of the upper Hanalei Valley for hunting and fishing. Increased pressure could lead to a decrease in the naturally occurring resource. Hanalei River supports an ethnic goby fishery. The river is frequently utilized by fishermen and provides an important sport fishery on the North Shore of the island. Fishermen are frequently seen on the mid to upper reaches of the Hanalei River. To preserve this important fishery it is important that the instream flows for the project be established following completion of an IFIM study on the affected portions of the Hanalei River and its tributaries. The determination of the conservation flows needs to be in coordination with the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service and the State of Hawaii Division Aquatic Resources. The applicant is currently negotiating with the U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers for the agencies to complete the IFIM studies to be utilized in establishing minimum bypass flows for the project. Under preliminary arrangements the studies would be performed by the agencies and funded by the developer. This type of an arrangement has been proposed because there are no sufficiently qualified people available in the islands of Hawaii in the private sector to provide this type of work. The only qualified individuals work with governmental agencies or are associated with the universities. Completion of the IFIM studies and determination of the conservation flows for the project will assure the preservation of the resource and preservation of the recreational fishery in the area.

The river is one of seven streams on Kauai in the Nationwide Rivers Inventory, a listing of the Nations significant relatively natural and free-flowing streams (National Park Service 1982). It is described as extremely photogenic. Project features will not be visible from the Hanalei Valley observation point with the exception of a portion of the .6 mile transmission line that will be constructed in conjunction with the project. The power line will be approximately 3 miles from the Hanalei observation point but would be visible in the background. An existing power line traverses that same area approximately 1 and 1/2 miles from the observation point. See Figure E-5 perspective sketch from the Hanalei observation point. The presence of the existing power line would tend to lessen the impacts of an additional power line that would be visible from the observation point. Figure E-6, Visual Analysis Map, shows the view sheds and project features as viewed from the Hanalei Valley observation point. As shown in the figure, no other project features would be visible from the observation point. The primary impact to the aesthetic resource would be to hikers, fishermen and hunters as they traverse the project area. Immediately prior to construction and during periods of project construction vegetation will be removed and the corridor for the penstock would be exposed. This will create a visual scar that would be obvious to people in the area. Construction activities would also create disturbances that would be visible in the immediate project area. None of these activities would be visible from the observation point. Figure E-7 shows perspective sketches of the Hanalei River Hydroelectric project features from various points and shows the visual intrusion of these facilities into those areas. The project has been designed to utilize low profile diversion dams and an above ground penstock that would be painted. The powerhouse will be built of earth



HANALEI VALLEY OBSERVATION POINT PERS

4

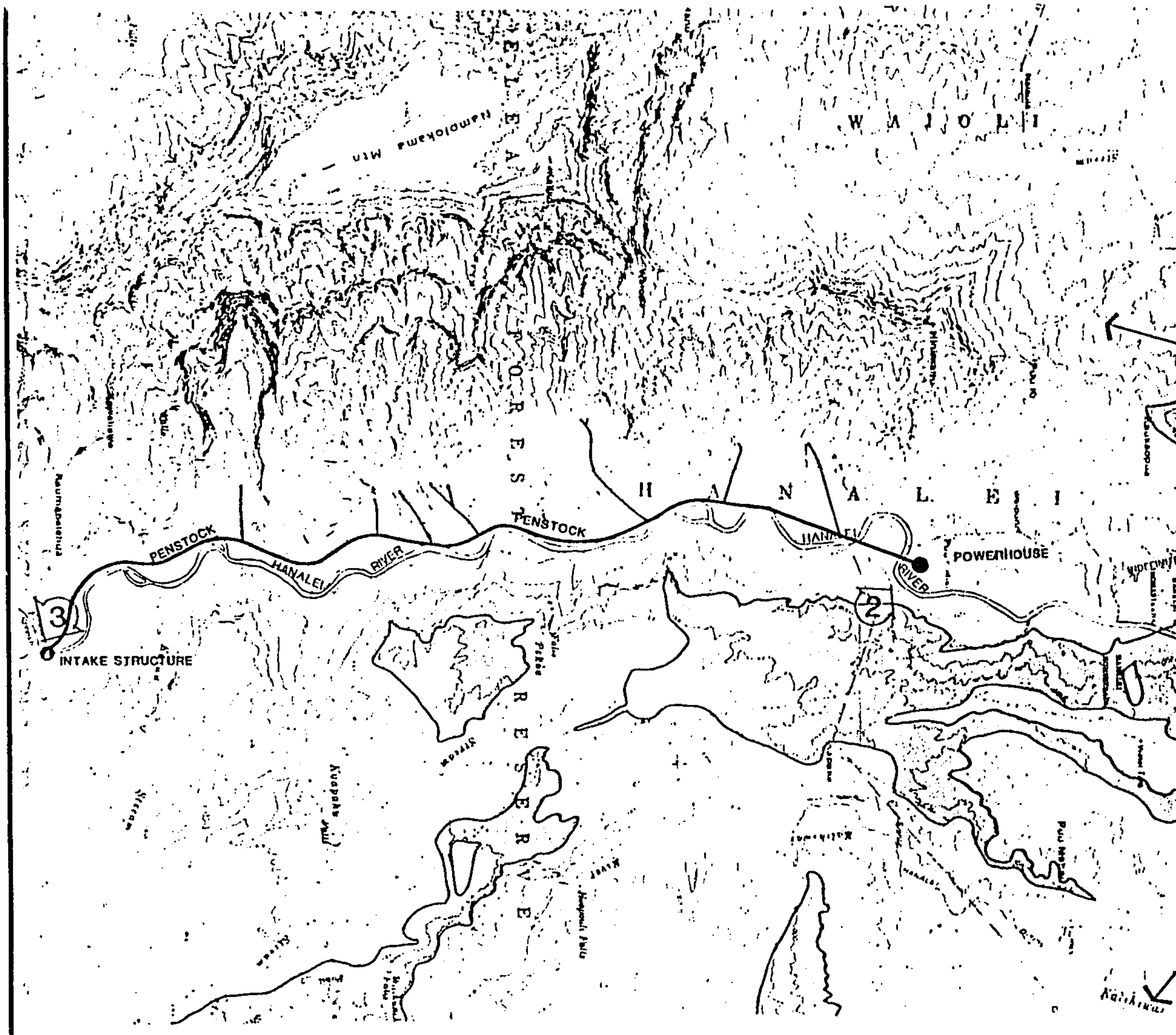


POINT PERSPECTIVE SKETCH

HANALEI HYDROELECTRIC PROJECT

PERSPECTIVE SKETCH

figure E -5

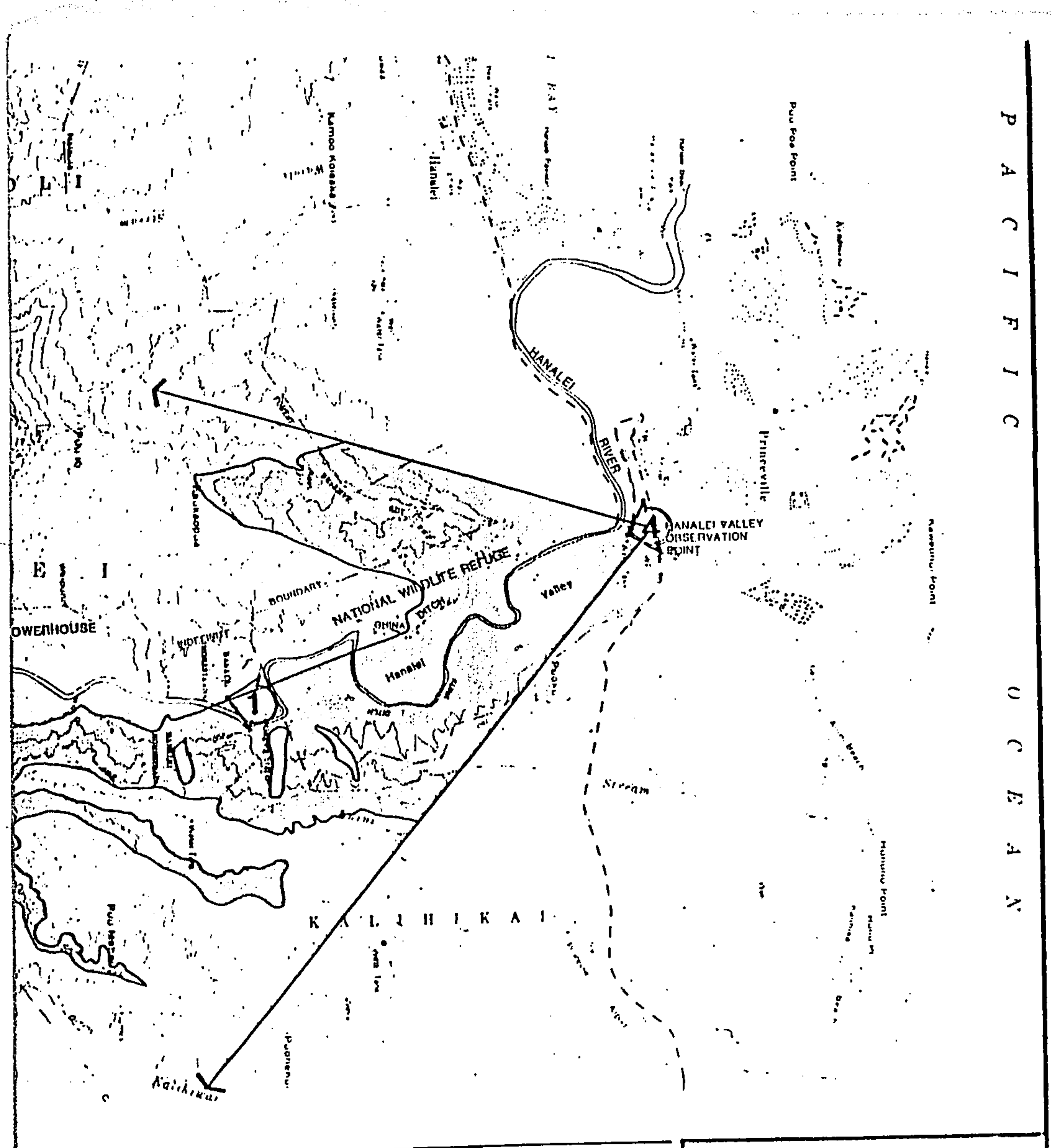


LEGEND

AREA SEEN FROM THE HANALEI VALLEY OBSERVATION POINT

1 PHOTOGRAPH & PERSPECTIVE SKETCH LOCATIONS

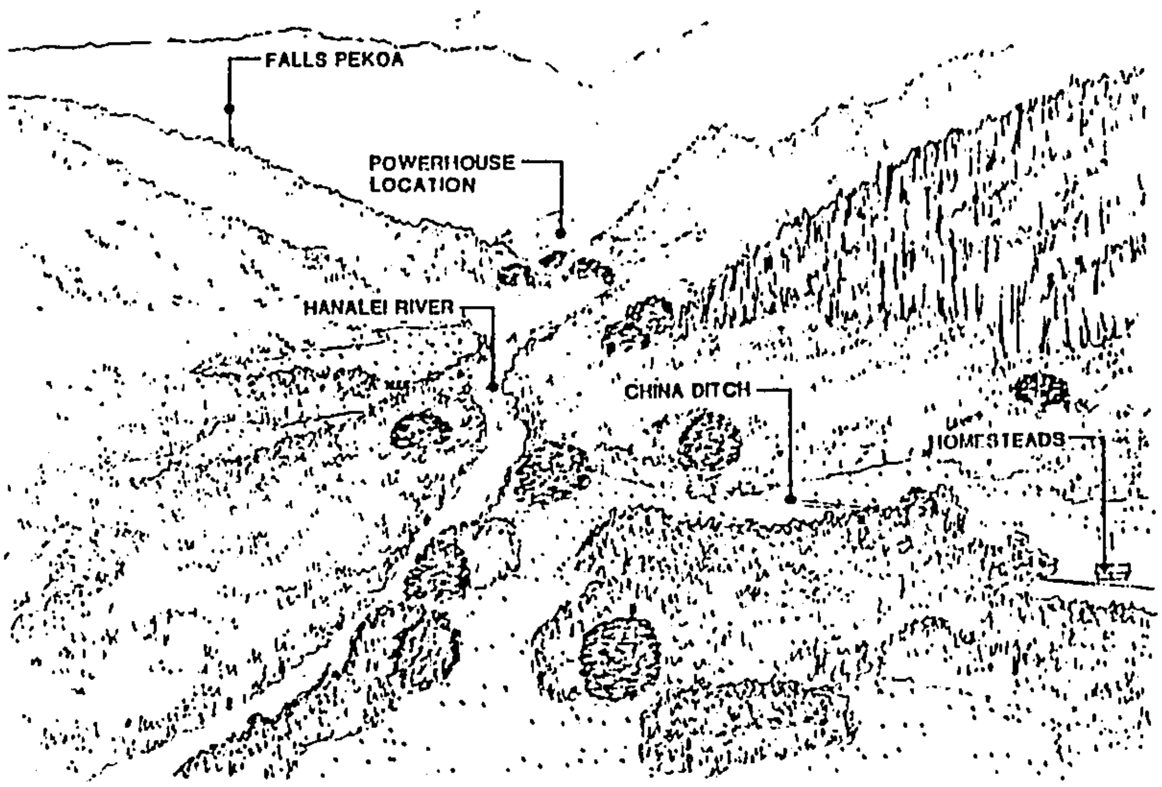
4 PHOTOGRAPH LOCATION ONLY



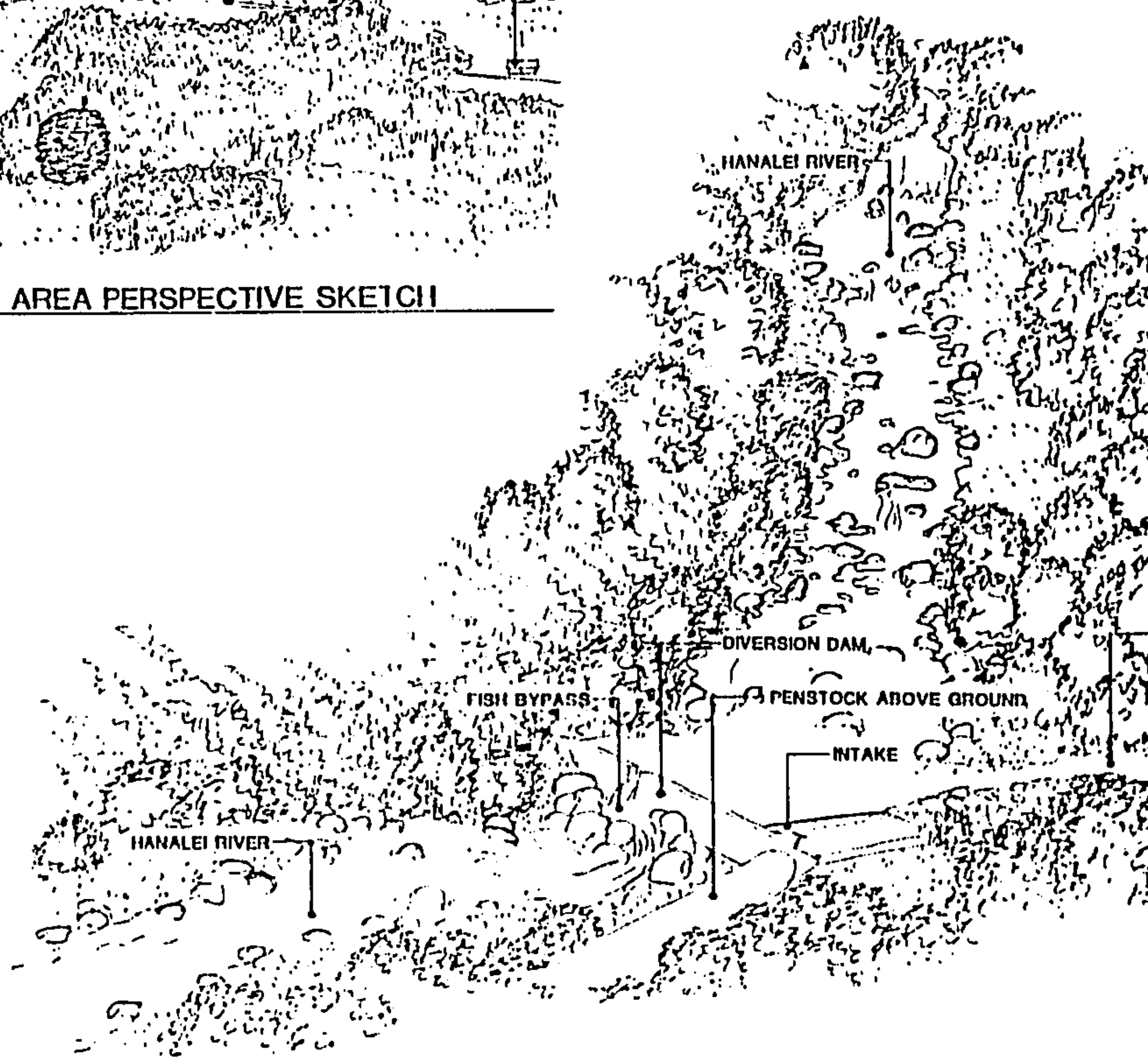
HANALEI HYDROELECTRIC PROJECT

VISUAL ANALYSIS MAP

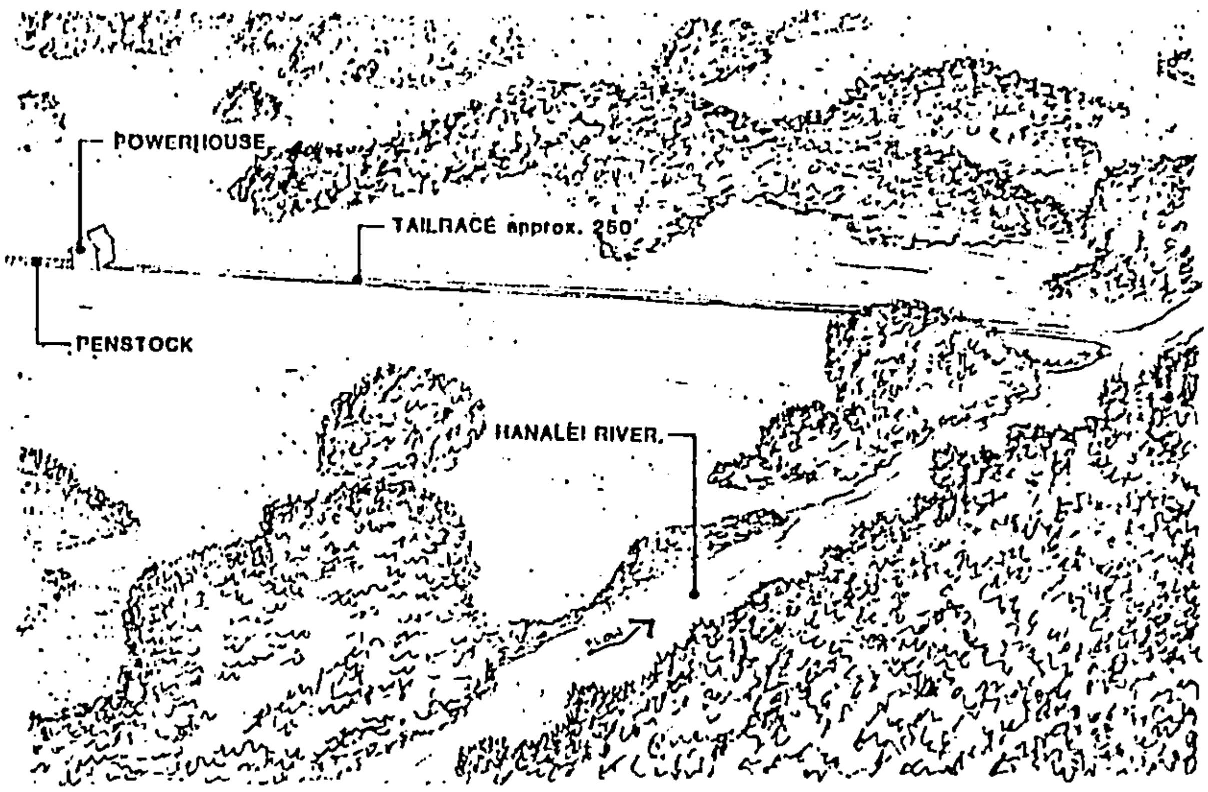
figure E-6



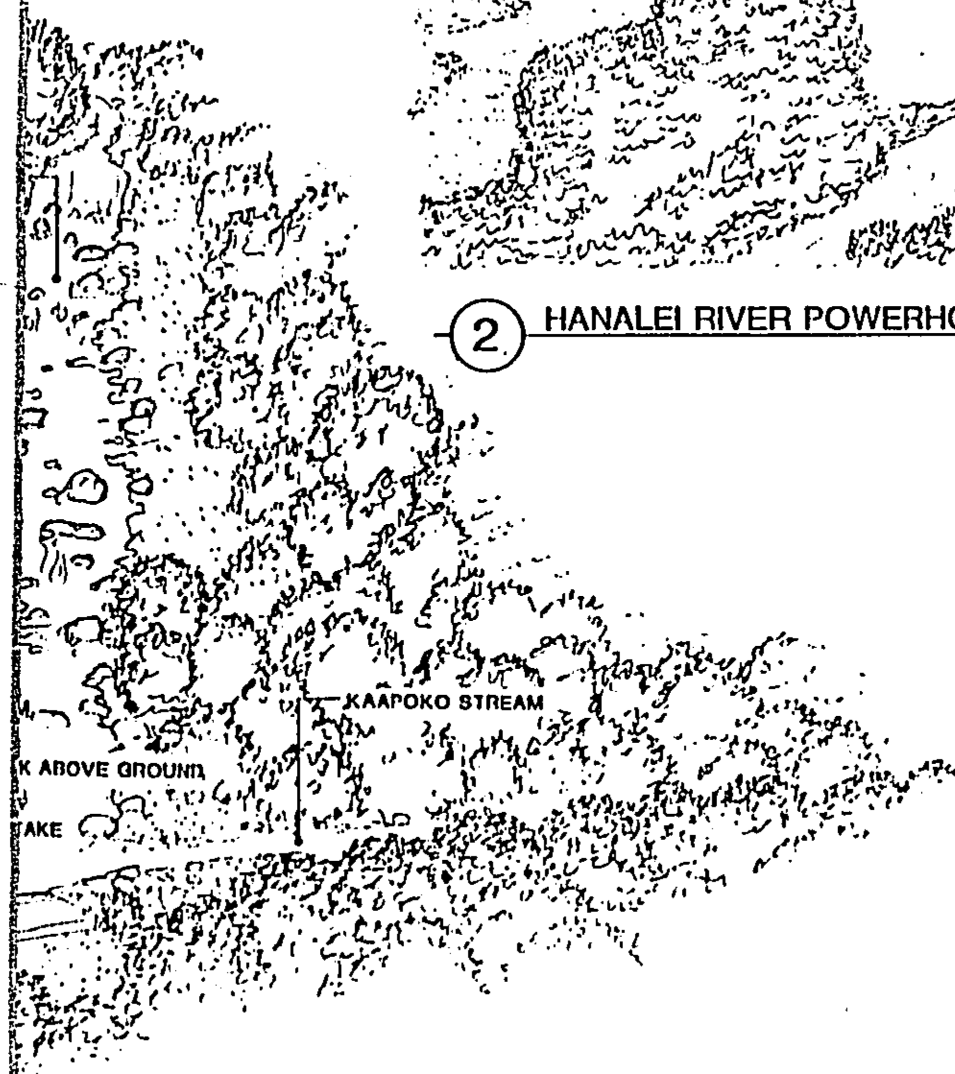
1 HANALEI RIVER DRAINAGE AREA PERSPECTIVE SKETCH



3 HANALEI RIVER DIVERSION STRUCTURE PERSPECT



2 HANALEI RIVER POWERHOUSE PERSPECTIVE SKETCH



RUCTURE PERSPECTIVE SKETCH

HANALEI HYDROELECTRIC PROJECT

PERSPECTIVE SKETCHES

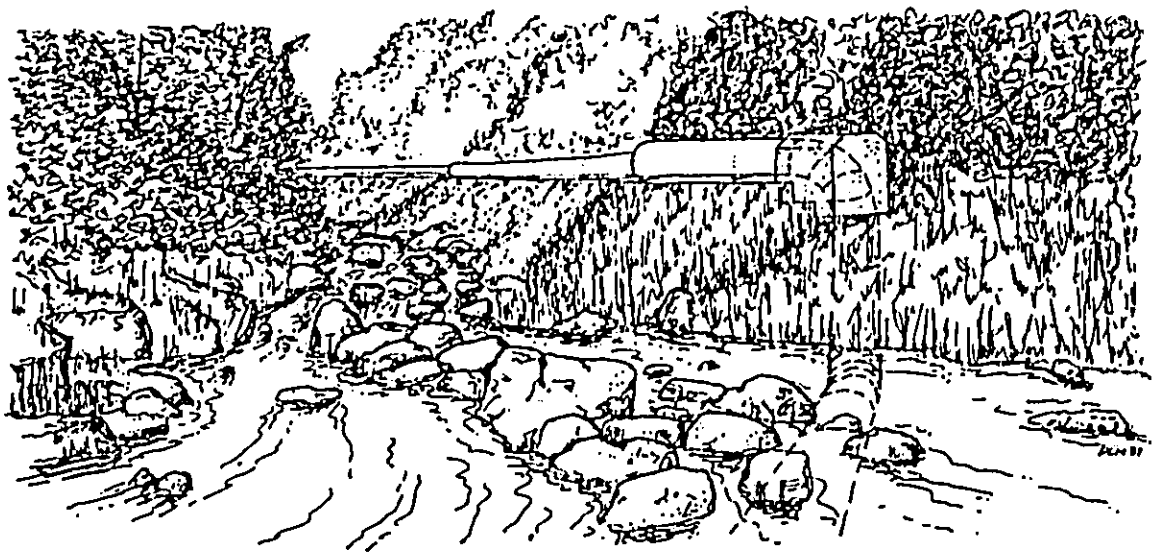
BINGHAM ENGINEERING

figure E-7

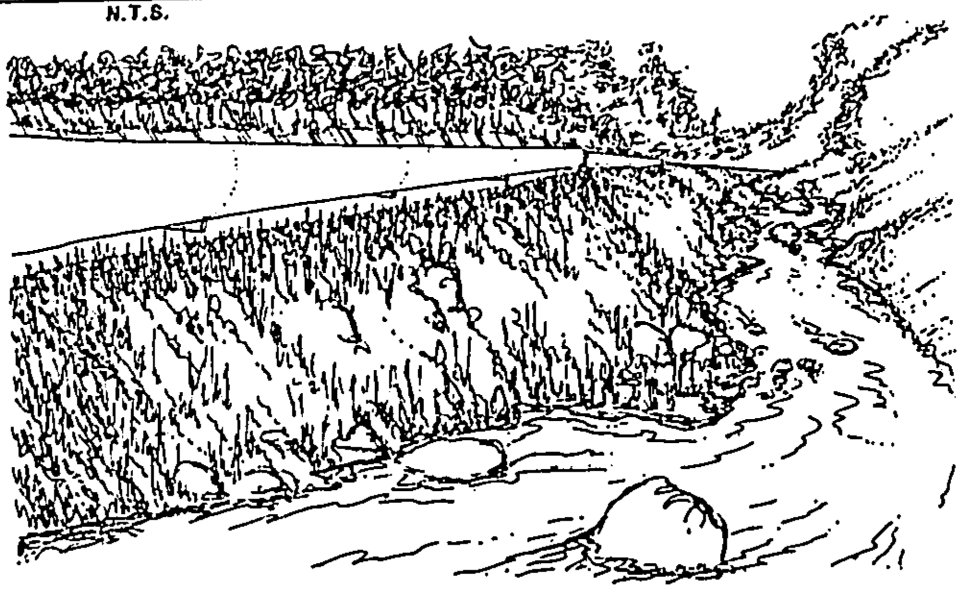
tone materials to blend in with the surroundings. It will be a low profile building. The greatest visual impact from the project would be to hikers, hunters and fishermen in the upper project reaches as they traverse the river. The penstock, although separated from the river and buffered with vegetation, would be visible at several points along the river. Figure E-8 shows perspective sketches of the penstock at the river crossings and typical river banks and on steep banks. The penstock will cross the river in a number of places. In the river section the penstock will be barried and riprapped. The penstock will be covered and revegetated from the river to where it comes above ground.

FOREST RESERVE AREA

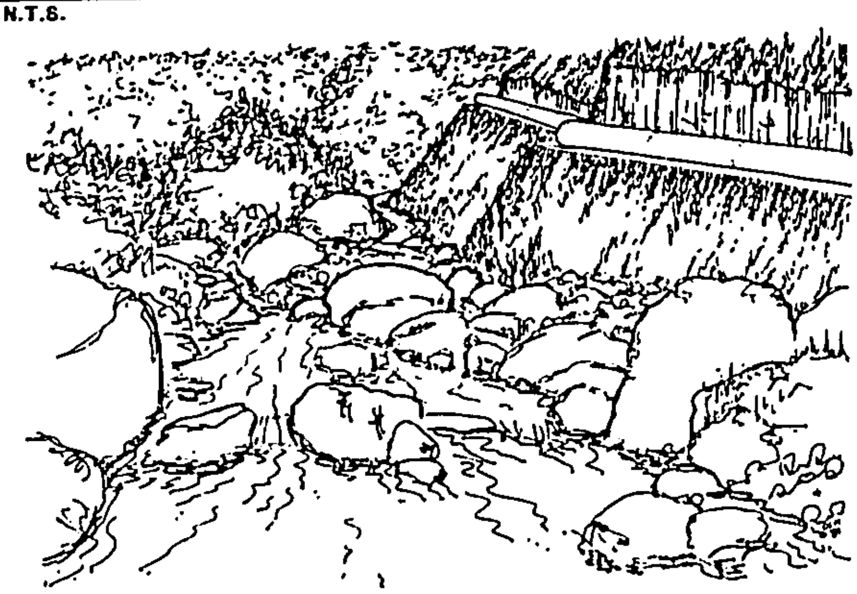
A corridor approximately 50 feet wide would be subject to selective removal of trees and other high vegetation along the transmission line alignment. Only vegetation that could come in contact with the power lines would be affected. The length of this corridor through the Halelea Forest Reserve is approximately 0.6 miles. A biological survey of the transmission line corridor through the Halelea Forest Reserve will be conducted prior to construction. Copies of the survey will be forwarded to the affected agencies and their recommendations will be incorporated in the construction plan prior to construction. To preserve the natural appearance of the Forest and to minimize the visual impact of clearing a 50 foot right-of-way, alignment will be angled up and down the ridge so that it can be screened by natural undisturbed vegetation.



PERSPECTIVE SKETCH OF PENSTOCK RIVER CROSSING
N.T.S.

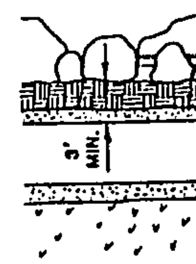


PERSPECTIVE SKETCH OF PENSTOCK ON TYPICAL RIVER BANK
N.T.S.



PERSPECTIVE SKETCH OF PENSTOCK ON STEEP BANK
N.T.S.

PENSTOCK (DIA. VARIES)
1' MIN. BEDDING MATERIAL
2' MIN. COMPACTE
FILL
REPLACED BOULDERS
EXISTING RIVER



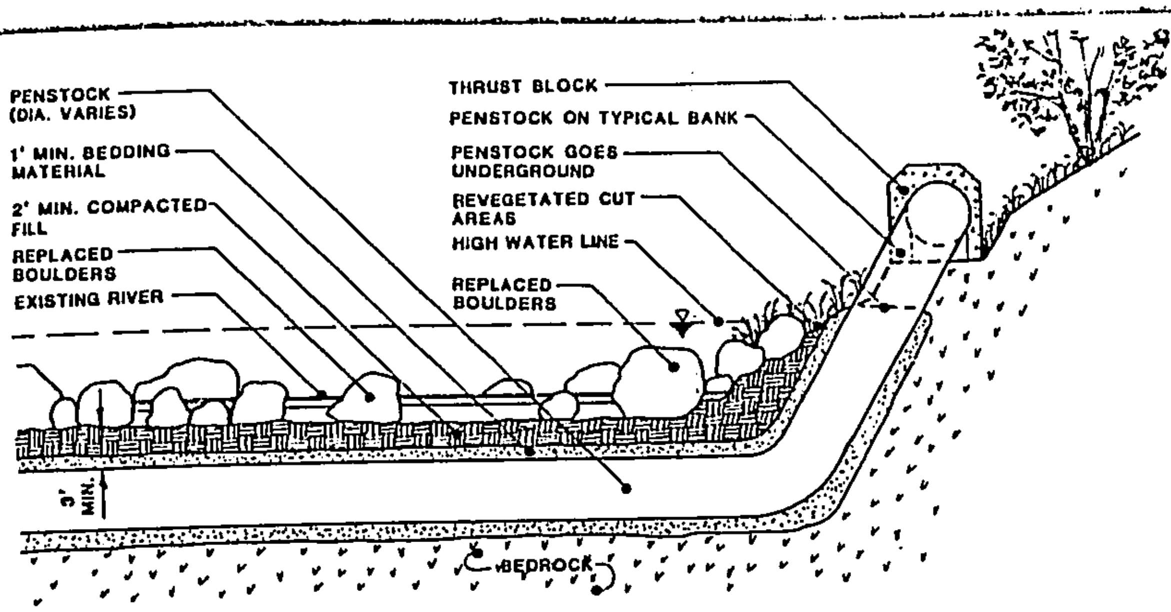
SECTION
SCALE: 1/8"

EXISTING SOIL C
REVEGETATED C
1/4:1 CUT SLOP
PENSTOCK (DIA.
CONCRETE SUPP
ROCK ANCHORS AS REQ'D
FILL SLOPE REVEGETATED
EXISTING SOIL COVER & VEGETATION

SECTIO
SCALE: 1/4

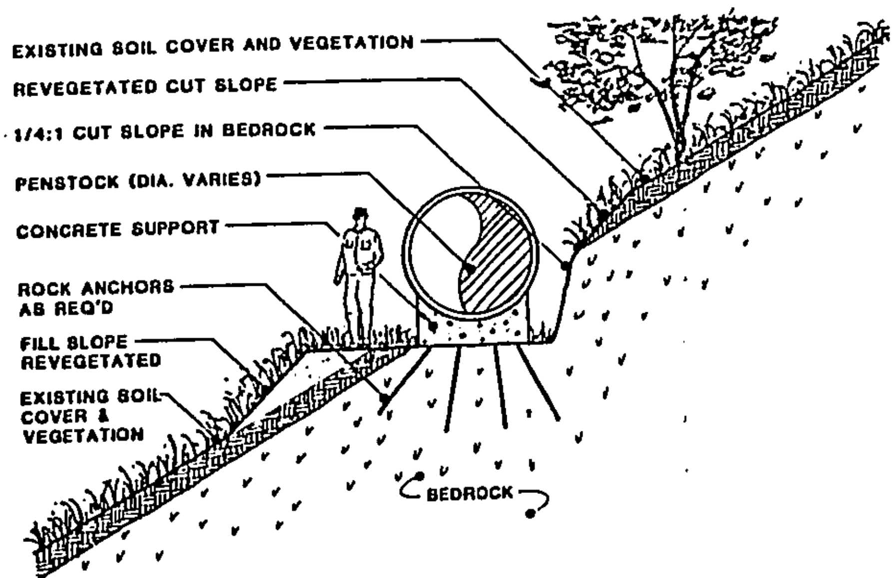
EXISTING VEGE
1/4:1 OR STEE
SLOPE IN BEDR
TRIBUTARY PE
(DIA. VARIES)
CONCRETE SU
ROCK ANCHO
AS REQ'D
EXISTING VEGETATION

SECTIO
SCALE: 1/



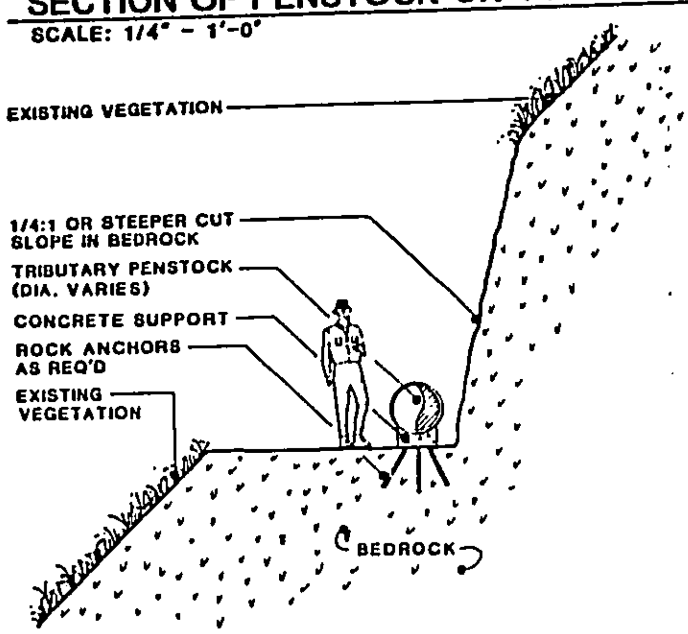
SECTION OF PENSTOCK AT RIVER CROSSING

SCALE: 1/8" – 1'-0"



SECTION OF PENSTOCK ON TYPICAL BANK

SCALE: 1/4" – 1'-0"



SECTION OF PENSTOCK ON STEEP BANK

SCALE: 1/4" – 1'-0"

BINGHAM ENGINEERING

Drawn D.C.Mutt

Date JANUARY '87 | Project # 621-04 | figure E-8

The proposed transmission line would affect 3.6 acres of Halelea Forest Reserve Lands mainly in the permanent loss of vegetation and trees within this corridor. This effect is not considered to be significant. The pre-construction archeological survey may determine that portions of the transmission line may require alignment changes to prevent significant adverse effects.

IMPACTS TO DOWNSTREAM WATER USERS

All irrigation diversions occur below the project reach. All water diverted for project operation will be returned to the river channel at the powerhouse.

Concerns have been raised about possible effects of the project on the estuary and agricultural land located below the project. There is very little information available on water quality and in these areas. In order to more adequately assess the impacts of development in these areas the applicant has agreed to cooperate with the citizens and the agencies in a proposed one year base line study of the North Shore area. The baseline study should not preclude the concurrent processing of the CDUA permit for the Hanalei project.

Resources and Values Identified in Section 122 of Public Law 91-611

Project related impacts on the environmental resources and values identified in Section 122 of P.S. 91-611 have been fully considered. Potential adverse impacts upon these resources resulting from project implementation are summarized below.

1. Air, Noise and Water Pollution

Air, noise and water pollution would be temporary impacts during construction of hydropower facilities. Effects on water quality have been discussed in other sections of this report. Minimization of these impacts would be effected by employment of construction methods that do not create excessive dust, hydrocarbon emissions, noise or turbidity. Environmental protection procedures and controls would be included in the project plans and specifications to insure compliance with applicable air, noise and water pollution regulations during construction operations.

2. Man-made or Natural Resources, Aesthetic Values, Community Cohesion and Availability or Public Facilities and Services

The project would not affect man-made resources, community cohesion and the availability of public facilities and services. Project effects on natural resources and aesthetic values have been discussed in other sections of this report.

3. Employment Effects and Tax and Property Values

Adverse employment effects and tax or property value losses would not result from implementation of the project.

4. Displacement of People, Businesses and Farms

Implementation of project alternatives would not result in the displacement of people, businesses or farms.

SUMMARY

Major Conclusions and Findings. The proposed project meets the primary objective in alternative energy resources development/conservation, contributing to the transition to an indigenous renewable energy economy. An evaluation of the effects on the discharge of fill material, in accordance with guidelines set forth in Section 404 of the Clean Water Act of 1977 indicates that the site and fill material are suitable for this purpose. No threatened or endangered species or their critical habitat would be permanently affected by the project. It has not been completely determined if known cultural resources eligible for or listed on the National Register of Historic Places would be affected by the plans. Final surveys will be conducted prior to project construction. If possible the alignment will be shifted to eliminate conflicts.

The relationship of the alternative plans to Federal and State environmental laws and regulations affecting this study are presented in Table E-9.

TABLE E-9

RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS

Federal Statutes	
Archaeological and Historic Preservation Act	Full
Clean Air Act	Full
Clean Water Act	Full
Coastal Zone Management Act	Not Determined
Endangered Species Act	Full
Estuaries Protection Act	NA
Federal Water Project Recreation Act	NA
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act	Full
Marine Protection, Research and Sanctuaries Act	NA
National Historic Preservation Act	Full
Rivers and Harbors Act	NA
Watershed Protection and Flood Preventation Act	NA
Wild and Scenic Rivers Act	NA
Executive Orders, Memoranda, Etc.	
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	NA
Environmental Effects Aboard of Major Federal Actions (E.O. 12114)	NA
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum)	Full

TABLE E-9

RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS (CONT.)

State and Local Policies	
State Land Use Plan	Full
Coastal Zone Management Program	Not Determined
Federal Coastal Zone Consistency Determination	Not Determined
State Environmental Policy Act	Full
County General Plan	Full
Special Management Area (SMA) Permit	NA

Notes:

Full - Full compliance, having met all requirements of the statute, E.O. or other environmental requirements for the current stage of planning (either pre-or post-authorization). In many cases full compliance will not occur until CDUA approval is received but compliance will be required prior to commencement of construction.

NA - Not Applicable, there is no requirement for the statute, E.O. or other environmental requirement for the current stage of planning.

F. ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

UNAVOIDABLE IMPACTS

Physical Environment. Construction activities will result in minor alterations of existing landforms. The natural terrain will be disturbed through common earthwork operation (clearing, grubbing, grading, trenching, excavating, and backfilling). Bulldozing will slighly alter the existing grade along the road alignment and disturb the existing soil regimes. If there is heavy rainfall during construction, earth moving activities could contribute to soil erosion around excavation sites and to sedimentation in low lying elevations. During construction approximately 38 acres of land will be disturbed.

At the diversion sites, the stream beds will be altered by the construction of low concrete diversion structures which will span the streams. Water quality will be affected by increased turbidity in the river during construction of the diversion structures. Strict compliance to County grading, erosion, and sediment control ordinances will be followed to minimize the potential impacts to receiving waters. Water temperature may rise slightly in the streams after water is diverted through the penstock for power production except in times of extremely high or extremely low flows. A conservation flow will bypass the diversions at all times except when the natural flow is less than the conservation flow. During these low flow times, no water will be diverted, and all available stream flow will remain in the natural stream course.

The pipe used to transport water from the diversion structures to the powerhouse will impact the visual quality of the site. The pipe will be, for the most part, installed above ground on concrete saddles. Diversion pipelines which lead from the diversion structures within steep gullies to the forebay will be installed on an excavated shelf in the canyon walls. Although the pipeline will be painted a non-obtrusive color and will be covered with vegetation after a few years, a visual impact will inevitably remain at the project site.

Temporary impacts on air quality are to be expected during the construction phase. The movement of construction equipment will increase the amount of air-borne dust and particulate emissions. Continuous dust-control measures will be employed in compliance with State and Federal particulate standards and regulations.

These same activities will increase ambient noise levels in the project area. At a distance of 50 feet, bulldozers and diesel powered trucks are expected to be the loudest pieces of noise-generating equipment. Construction related noise will be intermittent rather than continuous throughout the construction period and will cease upon completion of the project.

Biological Environment. Construction of the diversion structures and the temporary diversion weirs will disrupt the stream bed and the species who occupy those sites.

Accretion flows (the amount of flow that enters the streams between the diversion points and the powerhouse ditch) will supplement the conservation flow, and habitat in the affected reaches is expected to maintain current populations of aquatic fauna.

Native plants which lie in the construction zone will, unless specifically marked for protection, inevitably be destroyed. Installation of the diversion pipelines within the steep gullies will require the excavation of a bench along the pipeline alignment. This bench will be approximately 8' in width. Its construction will result in the loss of vegetation along the alignment approximately 25' in width where the canyon wall was a slope of 2/3 to 1. In less steeply sloped areas, the width of vegetation loss will be less. In some areas, it may prove feasible to install the diversion pipeline on metal or concrete supports anchored to the canyon wall. In these areas the loss of vegetation will be less than 25' in width because a bench cut into the hill will not be required.

Human Environment. Construction activities will create short-term inconveniences such as dust, noise, and traffic disruptions. Ambient air quality may be temporarily affected by dust and vehicle emissions, but primarily within the forest reserve rather than residential areas. Noise will be generated during all phases of construction activities, and will present a temporary nuisance to hunters, hikers and private living within the Hanalei homestead area. Construction vehicles will contribute to already existing traffic congestion on the Kihio Highway.

G. ALTERNATIVES TO THE PROPOSED ACTION

THE WITHOUT PLAN CONDITION

The "without plan condition" is the projection of the basic demographic, economic, and physical parameters to the project area. This projection condition is assumed to exist prior to the implementation of the selected plan of improvement and is used to evaluate the effects of each of the alternative plans.

PLANNING CONTRAINTS

Based on the foregoing analysis of the existing condition and future plans, the without plan condition is limited by certain planning constraints which may constrain the attainment of the desired levels of economic or environmental output.

The nature of the existing power plant features and the state of energy technology clearly point to the continuation of conventional fossil-fuel plants for the electrical utility on Kauai. The most likely alternative system will be the utilization of fossil fuel units.

The consumption of electrical energy will continue to be a function of the long term economic growth and normal increases in population. However, unless consistent and concerted effort is provided through a combination of personal initiative, normal technological changes, economic elasticity effects, and governmental programs, the overall growth in both peak demand and energy is expected to remain at current projected levels.

The topographic and landform features of the Hanalei River basin make large scale dam and reservoir features relatively costly to construct. The general drainage slope although mild by Hawaii standards, is steep enough to limit effective reservoir impoundment. In addition, as demonstrated by the prior State of Hawaii Waialeale study, locating a large structure upstream would not fully control hydrologically significant portions of the drainage area.

The Hanalei River is perennial and the amount firm flow available for power production is low at the U.S.G.S. streamflow Station 16101000, the discharge has historically been as low as 10 cubic feet per second. Hence, any proposed small hydropower facility would be relatively limited in scope consistent with hydrologic limitations.

The Hanalei River watershed is substantially influenced by the transbasin diversion of flow through the Hanalei tunnel into the Wailua River for agricultural uses related to the sugarcane industry. The upper elevations are designated conservation lands under ownership and use-control by the State of Hawaii. However, the lower areas above the urbanized strips along existing roadways are largely used in active taro production.

The environmental attributes of the Hanalei River basin are highly influenced by man's utilization of the area. The Upper Hanalei Basin contains heavily forested vegetation relatively secure from human encroachment. There are no known endangered species, wildlife refuges, sanctuaries, designated municipal water supply or prime natural recharge areas within the Hanalei River reaches affected by the project.

The aesthetic resources include the natural waterway and adjoining lands along the river. Acces to the river along the diverted reach can only be accomplished on foot.

Although the Hanalei area has been a major center of cultural and political development in ancient Hawaiian times, there are currently no historic properties listed or eligible for listing on the National Register of Historic Places in the potential area of improvement. A cultural reconnaissance survey was undertaken and no culturally significant remains were found. However, portions of the area contain agricultural terraces which may concern material appropraite for further investigation or preservation.

The economy of Kauai prior to the early 1960's was dominated by the sugar industry. However, during the last two decades tourism has reached a prominent position. Business, labor and associated commercial enterprises will continue to reflect these two major industries.

Kauai, similar to the islands of Molokai, Maui, and Hawaii, is less populated and more rural in lifestyle and activities than Oahu. Various commercial and private development projects over the past several years have generated public attention and interest. Community sentiment appears, in general, to support the relatively non-urbanized setting and living patterns.

DESCRIPTION OF THE "WITHOUT PLAN" CONDITION

In summary, the without plan condition will be considered to consist of the following technical, economic, environmental, and socio-institutional elements.

Technical. The existing mix of power plant types available to the island's utility will continue and be relatively unaffected by potential new hydroelectric plant facilities. The current patterns of peak demand and rate of growth for both demand and energy will continue at present levels. The existing state of irrigation ditches and diversions will continue at existing locations and rates of flow.

Economic. The economic growth of Kauai will continue to progress at present rates. The major dependent elements will be the progress and contribution of the tourism and agricultural sectors of the economy. The sugar industry will also continue to exist at present locations and extent. Any significant change in the role of sugar is highly subject to individual management decisions by the respective parent companies of the plantations related to worldwide sugar prices and U.S. support. Hence, any projections of decline or expansion of the sugar industry would be speculative.

Environmental. The existing ecological, aesthetic, and cultural resources will continue to exist in the present condition. The flora and fauna will propagate without significant external encroachment and adversity.

Socio-Institutional. The public will continue to value the worth of the scenic and agricultural setting of the Hanalei Valley. This perception is especially important in view of the physical and financial aspects of large construction projects. The State of Hawaii (through the Department of Land and Natural Resources) and the County of Kauai as well as the local utility will also maintain their present open and receptive positions regarding construction, energy, and public works endeavors. The Federal government will continue to provide institutional and financial support for new hydropower development.

SUMMARY OF STUDY PROBLEMS AND CONSTRAINTS

In terms of significance of problems and constraints, the following major items must be addressed in the project's impact analysis and contribution to economic development.

a. Dependence on Petroleum-based Power Plants. The island of Kauai is currently and will, in the foreseeable future, be highly dependent on petroleum-based fuels for electrical utility generation. The immediate problem is the alleviation of this dependence such that economic productivity and growth will not be stymied by external oil price fluctuations.

b. Recreational and Aesthetic Resources. The Hanalei Valley is one of the attractive recreational and aesthetic resources on the island. The proposed project would not be visually evident from the popular tourist lookout.

c. Potential Consumer Impacts. The principal public concern in the potential impact on consumer electric utility rates. This concern is related to dependence on petroleum-based fuels. If the dependence is decreased then the rate of price increase will tend to decline.

PLAN FORMULATION RATIONALE

The formulation and analysis of alternative plans was made considering the relationship to technical, economic, environmental, and socio-institutional factors.

TECHNICAL CRITERIA

The following technical criteria were established in the plan formulation process:

a. Any structural features should be designed to withstand the maximum reasonable external and internal loading conditions to minimize failure potential.

b. The improvements should be sized in a manner for efficient utilization of the surface water resources for energy development.

c. Features should be designed to provide for adequate accessibility for operation and maintenance purposes.

d. Electrical generation and tie-in should be compatible with the existing utility system.

e. Any change in flow rate should not adversely affect the existing irrigation operations.

ECONOMIC CRITERIA

To realize economic benefits the following criteria were established:

a. The plans under consideration should, as far as practicable, maximize economic benefits.

b. The relative benefits and costs should be expressed in quantitative economic terms.

ENVIRONMENTAL CRITERIA

The following environmental criteria were established for the plan formulation process:

a. The plans should not significantly disrupt or destroy existing ecosystems within the area of improvement.

b. The plans should not significantly impair the scenic beauty of the Hanalei Valley through physical structures or major diminution of flow.

c. Any increases in flows along man-made or natural channels should be within reasonable capacity of the facility and not cause failure of banks or significant increase in sedimentation.

d. Potential cultural features exposed or documented through investigation in the area of improvement should be evaluated for preservation or other measures.

SOCIO-INSTITUTIONAL CRITERIA

The following socio-institutional criteria should guide the evaluation of alternative plans:

a. The plans should be consistent with County and State agency plans for the vicinity.

b. The plans should be generally acceptable to the public and various interest groups.

c. The plans should be compatible to the maximum extent practicable with existing laws, regulations, and public policies.

POSSIBLE SOLUTIONS

IDENTIFICATION

To effectively undertake plan formulation, all possible measures must be listed regardless of their potential contribution to the objectives or to the established technical criteria. Preliminary screening was performed to narrow the selection to candidate plans meriting detailed examination. Table G-1 lists possible solutions categorized in accordance to the opportunity factors previously described. These solutions are itemized in terms of generalized features and qualitiative evaluation without specific quantitative dimensions or impacts. The potential contributions are simply listed in terms of significantly positive (++), positive (+), uncertain (?), negative (-), and significantly negative (--) contributions.

DISCUSSION OF POSSIBLE SOLUTIONS

No Action. In accordance with current Principles and Standards, regulations, the alternative of taking no action is to be fully considered in the planning process. In the no action alternative, the future scenario would be no growth in either peak demand or energy consumption. Under this setting, no additional power plants or conservation measures would be warranted. The basis of this scenario would be essentially a static or declining population and accompanying economic rate of growth. The current projections of Kauai's economy and general planning direction do not support this solution. Since additional generating capacity will be needed, no further consideration of this alternative will be made.

TABLE G-1

POSSIBLE SOLUTIONS

	Measure	Opportunity Factors Addressed	Potential Contributions
a.	No action	Econimic objective	—
		Environmental objective	—
		Nonstructural	—
		Plans of Other Agencies	—
b.	New fossil fuel Power plant	Economic objective	+
		Environmental objective	?
		Nonstructural	—
		Plans of other agencies	+
c.	Electrical interties	Economic objective	—
		Environmental objective	?
		Nonstructural	+
		Plans of other agencies	—
d.	Conservation and solar hot water heating	Economic objective	+
		Environmental objective	++
		Nonstructural	++
		Plans of other agencies	++
e.	New bagasse power plant	Economic objective	+
		Environmental objective	-
		Nonstructural	—
		Plans of other agencies	-
f.	Wind power plant	Economic objective	—
		Environmental objective	-
		Nonstructural	-
		Plans of other agencies	-
g.	Hydropower retrofitting and development at existing dam sites	Economic objective	—
		Environmental objective	?
		Nonstructural	-
		Plans of other agencies	—
h.	New conduit hydropower diversion and power plant	Economic objective	+
		Environmental objective	?
		Nonstructural	-
		Plans of other agencies	+
i.	New dam/reservoir and hydropower plant	Economic objective	—
		Environmental objective	—
		Nonstructural	—
		Plans of other agencies	+

New Fossil Fuel Power Plant. The existing diesel, oil, and gas turbine fueled power plants will continue to function as dependable energy sources. The local utility has projected that, subject to other developments, new power plants may be required in 1989 (8 mw) and 1993 (10.0 mw) to meet peak demand and energy growth of the island. As shown in Table G-2, the price of Number 2 (diesel) and Number 6 (bunker) oils were fairly stable prior to 1974. However, as a result of the 1973-1974 Arab fuel embargo in 1974, the prices of both fuels took a quantum jump to practically double their former levels. In 1980 the fuel prices rose again sharply such that the prices of No. 2 and No. 6 oils experienced 6-fold and 9-fold increases, respectively, since 1969. As of the end of 1981 the fuel oil price was $28.90 per barrel and that of diesel oil, $41.57 per barrel. Recently, oil prices have sharply declined which has significantly reduced the price of this type of power production. However, oil prices have already begun to escalate from their 1986 low price of $10/barrel. Due to the unstable world market for oil and the State of Hawaii's goal to alleviate itself from oil dependence, this solution was not considered for further evaluation. Despite the current world oil surplus, the long term outlook of oil availability and prices do not appear favorable. High dependence on fossil fuel plants will simply be a continuation of high dependence on external and potentially unstable world-wide conditions. Based upon these considerations, it is very desirable that alternative methods of generation be implemented.

Electrical Interties. The Kauai Electric Division system is completely self-contained within the island of Kauai. The utility is one of the two

TABLE G-2

LIQUID FUEL COST FOR ELECTRICITY GENERATION, KAUAI[1]

	Fuel Oil (No. 6)		Diesel (No. 2)	
Year	Cost, $/bbl	Avg. Annual % Growth	Cost, $/bbl	Avg. Annual % Growth
1969	2.78	--	6.03	-7.5
1970	2.95	6.1	5.88	-2.5
1971	4.11	39.3	6.20	5.4
1972	4.34	5.6	6.21	0.2
1973	4.84	11.5	6.92	11.4
1974	12.21	152.3	12.57	81.6
1975	11.50	-5.8	14.10	12.2
1976	11.96	4.0	13.96	-1.0
1977	12.57	5.1	16.28	16.6
1978	12.69	1.0	16.58	1.8
1979	16.23	27.9	23.96	44.5
1980[2]	24.21	49.2	35.53	48.3
1981[2]	28.90	19.4	41.57	17.0

[1]Average price of fuel consumed during calendar year. Sources 1969-1979: State of Hawaii, DPED. Hawaii Integrated Energy Assessment. Vol. IV, Honolulu: 1980.

[2]Sources: Hawaii, State of, Public Utilities Commission. "Annual Report of Kauai Electric Division of Citizens Utilities Co." for years ending December 31, 1980 and December 31, 1981.

smaller utilities in the state, the other being Molokai Electric Company. The remaining systems in the islands of Oahu, Maui, Lanai, and the Hawaii are controlled by the larger Hawaiian Electric Company (HECO). Kauai Electric, as a result, does not have financial and institutional ites to the other islands utilities.

Technically, submarine high voltage power cables to the depths required between islands are still in the developmental stage. To date (June 1981), the deepest high voltage direct current cables are deployed in water depths of 1,800 feet. The depths of Kauai Channel between Oahu and Kauai is deepest among all the major Hawaiian Islands, down to 10,800 feet and would have to be 73 miles (at the water surface) long. Plans are currently underway to initiate a $12.4 million feasibility study to investigate intertie between the islands of Hawaii and Oahu. The maximum depths would be 7,500 feet and a distance of 150 miles. The technical difficulties of structural/mechanical stresses, water tightness, sheathings, and conductors have not been resolved for very deep cables. Due to the institutional and technological problems and potential enormous cost (on the order of $1 million per mile)[1] this potential solution was not considered for further evaluation.

Conservation and Solar Hot Water Heating. Conservation measures, including solar hot water heating, have received considerable publicity, commercial advertising, and government support. The encouragement of

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[1] Hawaii, State of, DPED. Hawaii Integrated Energy Assessment Vol. II., Honolulu: 1981.

energy conservation has been one of the pilliars of the national energy programs since the President's address to Congress of 20 April 1977 and has been adopted as one of the evaluation criterion in the Other Social Effect (USE) account of Principles and Standards.

Outside of existing biomass (bagasse-fueled steam plant) and hydropower alternative energy sources, the other existing technology which will significantly contribute to Kauai's electrical system is solar energy. Although ultimately all sources of energy are directly or indirectly attributable to solar thermal energy conversion (SETC), photovoltaic (PV) conversion and solar collector/heat exchange systems. STEC systems are large, centralized power facilities which include collectors, thermal storage, and turbogenerators. The PV conversion system utilizes direct conversion of solar energy to electrical current when sunlight strikes semiconductor cell devices. The economic application of either solar thermal energy conversion or pnocovoltaics in Kauai is estimted to be approximately 10 years in the future. Significant technological development and marketing techniques still remain. Hence, no further discussion of these two categories of solar technologies will be presented.

The remaining color technology applicable for kauai is solar collector/heat exchange. Solar hot water systems have been highly accepted systems in Kauai as well as other Hawaiian islands. Unlike STEC and PV systems, solar hot water systems do not generate electricity, are consumer/conservation oriented and are decentralized and not directly controlled by the central utility entity. The system consists of flat plate collectors, liquid heat conductor elements, thermal storage and backup alternative thermal heating element.

Energy conservation is expected to make significant contribution to increasing the State's and Kauai's energy independence. Conservation will enable the island to consume petroleum fuels at a slower rate and serve as a partial moderator until effective alternative energy technologies are implemented. The qualitative evaluation of opportunity factors suggest that this potential solution does offer potential as a viable solution.

New Bagasse Power Plant. Bagasse is the fibrous material remaining after the extraction of juices in sugar mill operations. This waste product is the plantation's main source of fuel. The gross heat value of bagasse fiber is 8,350 8 tu/lbs and roughly 1 ton of bagasse will produce as much steam as 1 barrel of number 6 fuel oil when both fuels could be burned in the same boiler. Historically, because the electric utility system on Kauai originated from the sugarcane industry, bagasse-fueled power plants have continued to be a significant energy source. In 1980, prior to the implementation of the new Lihue Power Plant, bagasse contributed 78 million kwh, island wide, of which 16 million kwh[2] was sold to kauai Electric Division (KED). This sold energy amounted to 8.4 percent of the total electrical supplied by the utility.

With the rise in high petroleum cost and receptiveness of the public utility to price negotiations for bagasse-fueled energy, bagasse has risen in importance. The most significant development stemming from the new

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[2]Excludes contribution of boiler fuel oil.

financial scene, has been the completion of the Lihue Plantation's 20 MW boiler. The plant was the largest single construction project on the island of Kauai, completed at the end of 1980 with base cost of $25 million. The 1981 impact of this single project was that the bagasse-fueled contribution on the island rose to 146 million kwh, of which 73 million kwh[2] sold to Kauai Electric. This added energy increased the bagasse contribution to the electric utility to 33.3 percent. Including the use of boiler fuel oil, the new Lihue power plant produced 99.8 million kwh in 1981. As a result, the older 10 MW Lihue units installed in 1939, 1949, and 1957 have been essentially shutdown. Although the implementation of the Lihue power plant provides a lead step in and direction of energy self-sufficiency for Kauai, the contribution of new bagasse power facilities remains uncertain.

The future of bagasse-fueled power is highly dependent on the long term and economic well-being of the sugar industry in Hawaii. All 14 sugar companies in the State are either wholly - or partially-owned subsidiaries of five major agri-ousiness corporations: C. Brewer, Ltd.; Castle and Cooke, Inc.; Theo. H. Davies, Ltd.; Alexander and Baldwin, Ltd.; and Amfac, Inc. The sugar companies own interest in the California and Hawaiian Sugar Company (C&H) which refines and markets almost all (96 percent) of Hawaii sugar at its Crokett, California refinery. Hawaiian sugar plantations supply approximately 10 percent of the nation's sugar needs. On the island of Kauai, sugar is by far the dominant agricultural crop, totalling 45,800 acres out of approximately 48,000 acres or 95 percent of agricultural acreage.[3] The extent of sugar lands is shown on Figure G-3. However, considering the 22-month sugarcane growing cycle, the actual 1981 harvested area totaled 21,800 acres. Although over the past 20 years statewide sugar yields and acreages have remained relatively constant there have been ominous signs of economic problems. In recent years three plantations have closed opeartions (Kahuku on Oahu, Kilauea on Kauai, Kohala on Hawaii).

In retrospect and potentially in the future, several factors will both restrict and endanger the Hawaiian sugar industry. First, there are continued urban pressures upon the land. Several plantations are relatively close to urban areas (e.g., Oahu Sugar Company on Oahu. Pioneer Mill on Maui, Lihue Plantation on Kauai). Higher use and worth of lands may eventual cause the plantations to grant the development rights or to divest themselves of unprofitable lands. This may lead to decreased productivity and adverse economic scale effects for the remaining lands. Second, labor costs in Hawaii for sugar production are among the highest in the world. Unlike most mainland United States sugarcane workers, field and factory hands are unionized. In 1981, the industry-wide average annual wage was $16,700.[3] Third, the sugar industry has been subject to considerable uncertainty in world sugar prices. Most sugar-producing countries trade in controlled markets stabilized by government ownership, tariffs, subsidies, and related methods. Since 1950, the world's sugar prices fluctuated from 4¢ to 42¢

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[3]Hawaii, State of, Department of Planning and Economic Development. The State of Hawaii Data Book, 1982. November 1982.

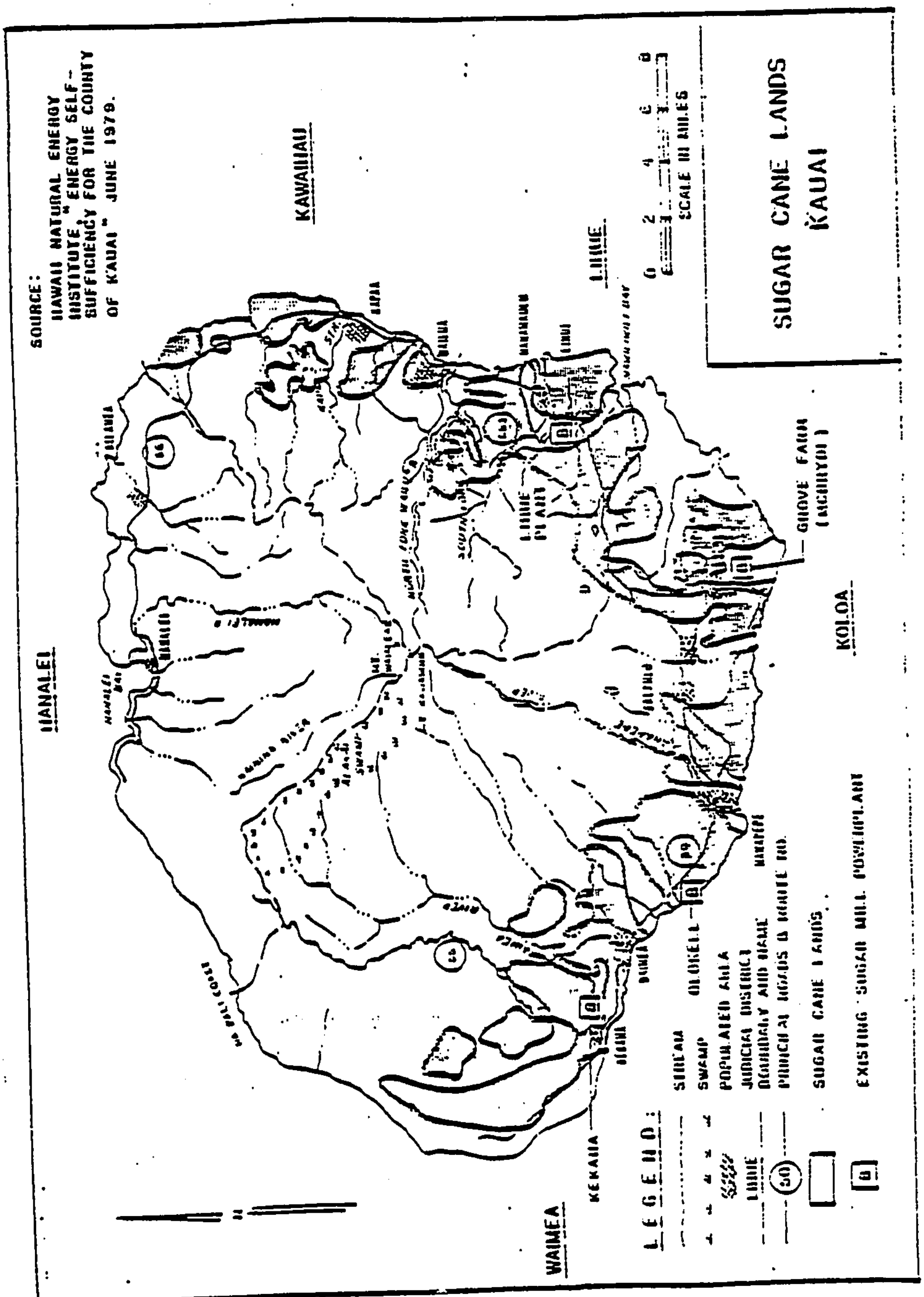
SOURCE:
HAWAII NATURAL ENERGY INSTITUTE, "ENERGY SELF-SUFFICIENCY FOR THE COUNTY OF KAUAI" JUNE 1979.
SUGAR CANE LANDS
KAUAI
0 2 4 6 8
SCALE IN MILES
HANALEI
KAWAIHAU
LIHUE
KOLOA
WAIMEA
KEKAHA
OLOKELE
GROVE FARM
LEGEND:
STREAM
SWAMP
POPULATED AREA
JUDICIAL DISTRICT BOUNDARY AND NAME
PRINCIPAL ROADS & ROUTE NO.
SUGAR CANE LANDS
EXISTING SUGAR MILL POWERPLANT

Figure G-3

per pound and sugar is acknowledged as the most volatile of 40 major commodities on the international market.[4] Although the U.S. sugar market currently is price controlled, there remains the danger of reverting to the "free market, subject to strong price fluctuations. Hence, the sugar industry lobby keeps abreast of possible adverse Congressional action.

Partially due to adverse prices, Hawaiian sugar industry has suffered dramatic losses. In 1981, the industry lost an estimated $83.5 million, of which Kauai's loss was approximately $22 million. In the seven-year period from 1976 through 1982, the industry has had five years of losses.[5] The net result in planning has been general conservatism and reluctance for costly capital and land improvements.

Bagasse production is not, of course, the principal purpose of the sugar industry. The sugar industry has not had projections of bagasse quantities. However, in analysis of the past production and availability of bagasse will provide insight on its future energy production. As shown by Table G-4 and Figure G-5, there has been a slight decline in bagasse production since 1973. An important trend has been the decline in the quantity of discarded bagasse. This apparently reflects a greater utilization of bagasse for the plantation's power plant. Assuming the harvested acreage of Kauai sugar industry remains relatively constant, the net long term

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[4]Hawaii, State of, Department of Planning and Economic Development. Hawaii's Sugar Industry. April 1981. Constant 1979 dollars cited.

[5]Honolulu Star Bulletin. "Hurrican Iwa Intensifies Plight of Sugar" 1 December 1982.

TABLE G-4

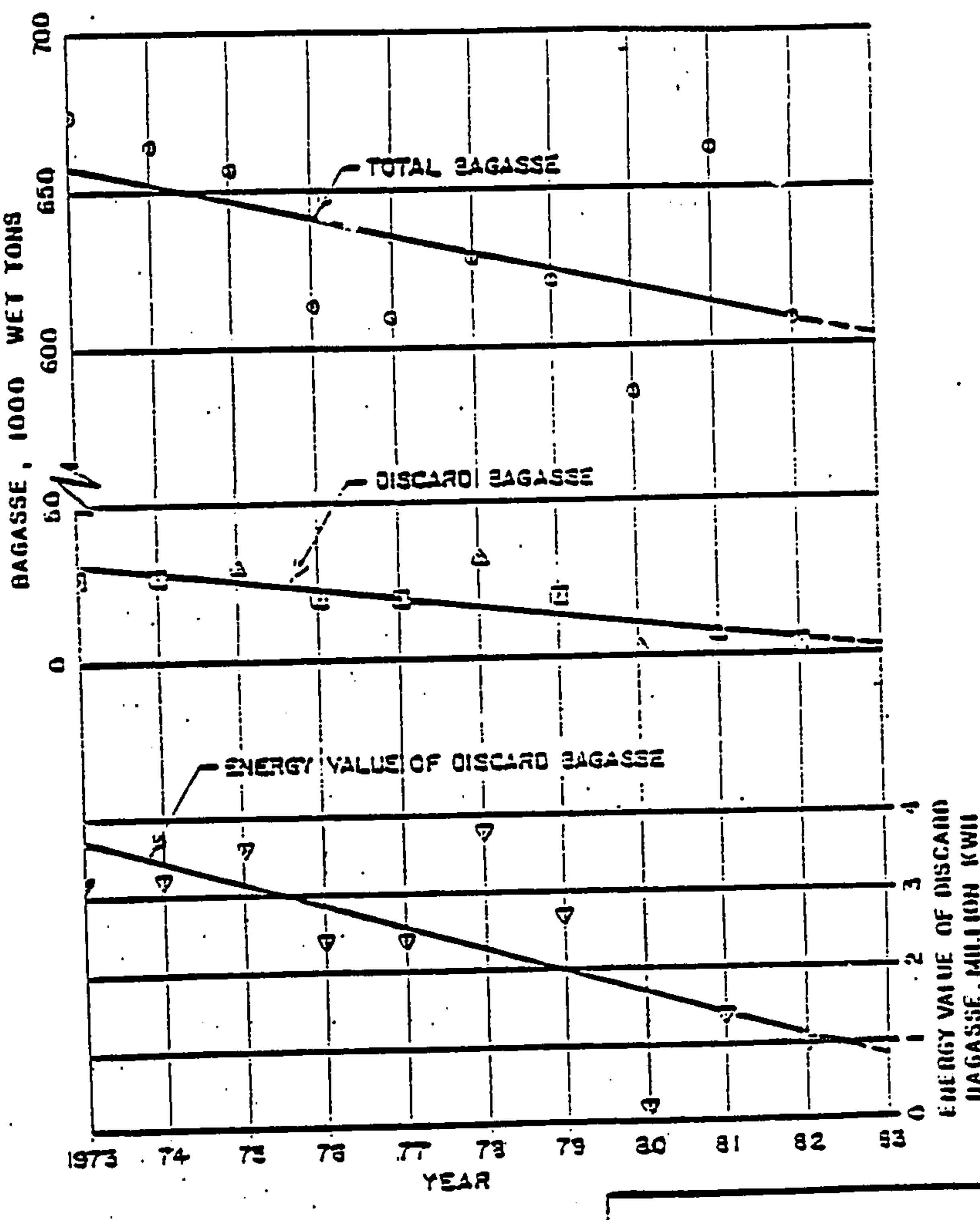
HISTORICAL BAGASSE PRODUCTION
ISLAND OF KAUAI

Year	Bagasse Production, 1,000 Wet Tons: Total[1]	Bagasse Production, 1,000 Wet Tons: Discarded[2]	Energy Value of Discarded Bagasse Million kwh[3]
1973	674	27	3.2
1974	665	27	3.2
1975	657	30[1]	3.6
1976	614	20	2.4
1977	610	20	2.4
1978	628	32[1]	3.6
1979	621	20	2.7
1980	585	2[1]	0.2
1981	663	6[1]	1.4
1982	608	4	1.0

[1]Actual data derived from Hawaiian Sugar Planter's Association and invidual plantations.

[2]Estimated except as noted.

[3]Computed.



LEGEND
- ⊙ △ ACTUAL DATA
- ⊟ ESTIMATED DATA
- ▽ COMPUTED DATA
- ▬ LEAST SQARE BEST FIT LINE

BAGASSE PRODUCTION FOR KAUAI

Figure G-5

annual value of discarded bagasse amounts to less than 1 million kwh. The sugar industry on Kauai is effectively utilizing its bagasse resources. In fact, during 1981 only one plantation disposed of excess of bagasse.

The potential contribution of bagasse-fuel power on Kauai remains relative constant. The Hawaii Integrated Energy Assessment,[6] the latest comprehensive analysis of the State's energy needs has projected a constant capacity and energy contribution of plantation steam plants (utilizing both bagasse and oil) under the baseline scenario. In the projection condition, it is recognized that bagasse production could be increased by growing high fiber sugar and utilizing marginal lands for fiber production. However, this would effectively alter the entire goal of the plantations from sugar production to fiber production, a change of far reaching consequences that no one is prepared to support at this time.

The Lihue 20 MW power plant has undoubtedly been beneficial to all interested concerns. The power plant was implemented by favorable instituational arrangement between Foster-Wheeler Corporation (the manufacturer), Lihue Plantation/Amfac (processing plant and land owner), and Kauai Electric Division (utility). The Foster-Wheeler Corporation, one of the nation's largest boiler manufacturers, fianced, built, and are the owners of the steam plant. In return for the investment, they will receive income from the energy produced from the plant over a 20-year period. Lihue Plantation provided the site location, would operate the plant, and

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[6]Lawrence Berkeley Laboratory, University of California and State of Hawaii, Department of Planning and Economic Development, Hawaii Integrated Energy Assessment. Vol. I, June 1981.

would share in electric revenues beyond the minimum 55.6 million kwh of energy. Kauai Electric would pay for the energy produced and control the plant operation to match the load. The KED contract was signed for a 20-year period and provided an escalated rate of energy prices depending upon the sugar grinding seasons, consumer price index, and price of oil at Port Allen. The total base cost of $25 million did not include the existing bagasse house, nor the implementation of an improved conveyor system, cooling tower, and wet stack scrubbers which would add an estimated $3.3 million.[7] When escalated to the October 1982 price level (from the base price level of October 1978), and including the effects of economic worth of lands and interest during construction, the investment cost would increase to $42.7 million, or $2,100 per kilowatt or capacity. If the plant were down sized to a comparable small hydropower plant of 5 megawatts, the high fixed cost would boost the unit cost up to $5,400 per kilowatt. This unit cost is not favorable when compared with hydropower facilities.

Due to economies of scale, it would be infeasible to install small modular boiler turbo generators unless the excess low pressure steam were marketable in addition to the energy sales. Rehabilitation of existing steam generators has been considered by several plantations. However, because of uncertain economic future of the industry the plans have not progressed beyond concepts.

Finally, the implementation of the Lihue power plant may be considered

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[7]Personal communication with officials of Forster-Wheeler. E. E. Black and Amfac, May 1983.

practically unique in its institutional setting amidst a favorable economic climate. The financing of such a large private endeavor requires the availability of funds (as in Foster-Wheeler case), feasibility of improvements at an existing sugar plant (as with Lihue Plantation), receptiveness of the local utility (Kauai Electric) and accompanied by governmental approvals (State Public Utilities Commission and the U.S. Environmental Protection Agency). A related project on Oahu, formerly known as Honolulu Program of Waste Energy Recovery (H-POWER), designed to extract energy from solid municipal waste has met significant political and social opposition and uncertainty for the past two years. There would also be a large risk of hurdling the financial, institutional, and social elements for a similar biomass power plant on Kauai.

In summary, the factors of the uncertainty of the sugar industry, the effective negligible quantities of additional bagasse, the relatively high fixed cost of comparable bagasse-fuel power plant and the unlikely repetition of a financial/institutional arrangement similar to the Lihue power plant, makes the implementation of the new bagasse power system improbable for the near future. For these reasons, the bagasse system was not considered for further evaluation.

<u>Wind Power Plant.</u> Wind power has historically been in use since the 14th century for irrigation, pumping, and grinding grain. However, in recent times most technical programs were phased out with the introduction of inexpensive gas and oil fuels. By the early 1970's with the shortages of cheap petroleum, developmental programs were resurrected by leading industrial nations. From FY 1977 to FY 1983 the U.S. Department of

Energy (DOE) had been authorized almost $300 million for various programs for demonstration and commercialization of wind energy conversion systems (WECS).[8] In the State of Hawaii, the principal result has been the data acquisition, construction experience, and performance study of the joint DOE/Hawaiian Electric Company 0.2 megawatt MOD-OA turbine located at Kahuku, island of Oahu. From May 1980 to November 1981, the unit had generated 1.2 million kilowatt hours and registered a plant factor of 46.3 percent.

With this increase emphasis on alternative energy systems, estimates of wind regimes power potential throughout the State have been prepared. According to estimates prepared under the Hawaii Integrated Energy Assessment (HIEA) program, Kauai would achieve significant wind generating capacity by the year 1995.[9] Under the baseline future scenario ("Future 1"), as much as 22 megawatts of capacity and an additional 77 million kilowatt hours of energy would be possible. Prior to 1995, the wind contribution would be negligible. Admittedly, the "potential" for wind power is not well defined and must be tempered with the knowledge of other considerations.

The wind environment on Kauai is not as advantageous compared to other counties. For example, based on the same HIEA projection conditin, for Honolulu, Maui, and Hawaii counties and the wind potential would be 370

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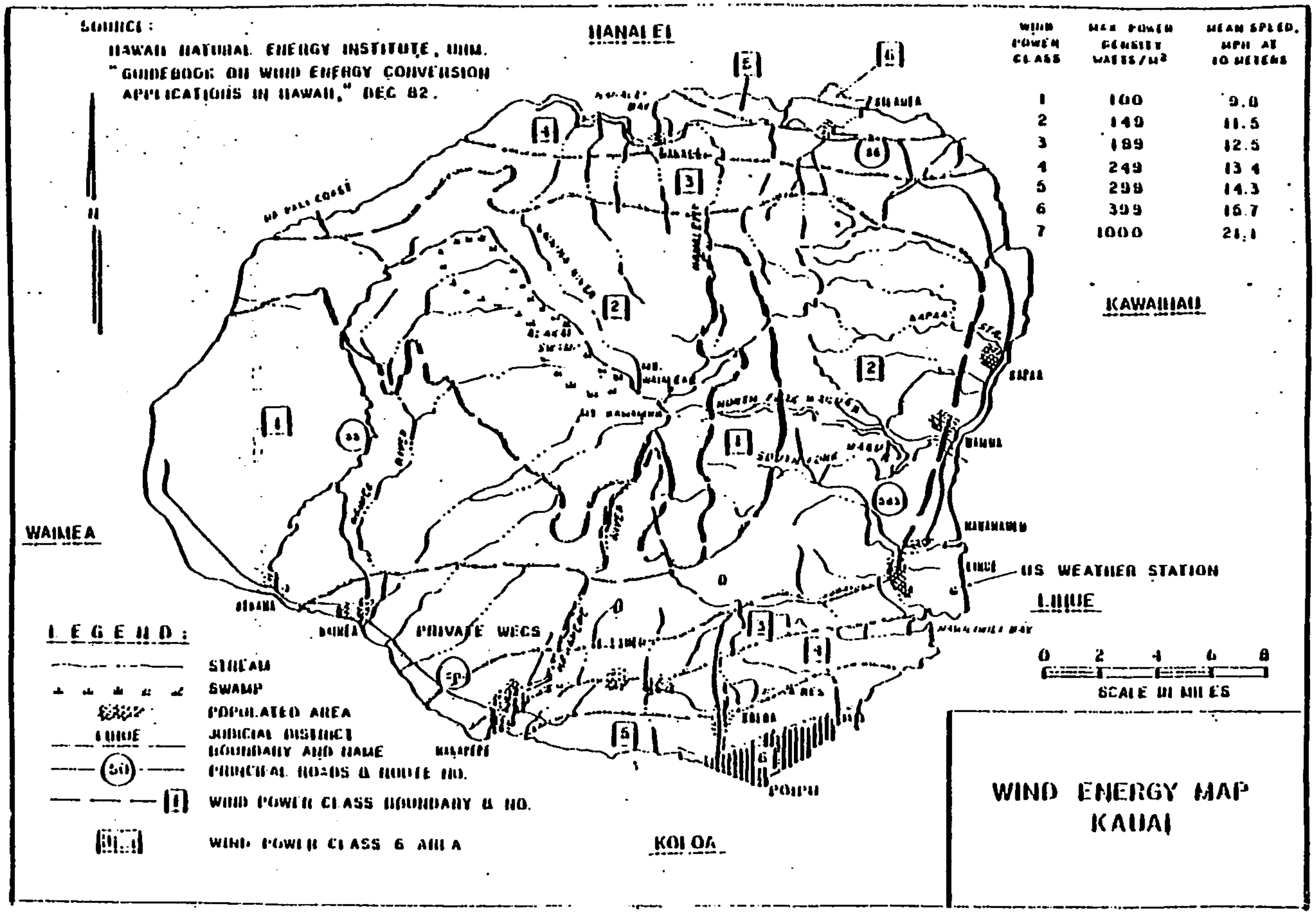
[8]Personal Communication. U.S. Department of Energy, Honolulu Area Office. May 1983.

[9]Lawrence Berkeley Laboratory, University of California and State of Hawaii. Department of Planning and Economic Development. Hawaii Integrated Energy Assessment. Vol. I, June 1981.

megawatts, 32 megawatts, and 51 megawatts, respectively. The key factors related to favorable siting are high mean wind speed, minimal local turbulence, reliable wind turbo-generating hardware, available and institutionally approved lands, proximity of high voltage transmission lines, and construction accessibility. These factors are very site and project specific. However, generalizations may be inferred from a locational analysis of mean wind speed. To implement a feasible utility-type WECS, mean wind speeds of 15 miles per hour are desirable. As related to wind power densities, a site should be located in wind power classes 6 or 7 (at 10 meters in height). On Kauai, as shown by Figure G-6, there exists only two suitable small areas, one located near Kilauea and another at Poipu. In contrast, on the island of Oahu, the entire Koolau mountain range, Waianae mountain range and the Kokohead areas are designated within these classes. The island of Molokai and Hawaii also have similar favorable, large areas.

With the incentives of Federally-funded research and development, energy tax credits, and competitive marketing by numerous wind turbine manufacturers, there have been a number of WECS installed throughout the State. Despite the optimistic forecast, none have been installed as either part of an island's utility system or which would provide capacities approaching utility application (equal or greater than 0.1 MW). The cumulative total capacity of all small scale WECS, installed Statewide, is approximately 1.5 MW. The largest facility planned to date is an 80-megawatt windfarm located near Kahuku, Oahu. The proposal has been delayed since development plans were initiated in 1979 due primarily to lack of a satisfactory turbine system. The target unit cost is $3,500 per



SOURCE:
HAWAII NATURAL ENERGY INSTITUTE, UHM.
"GUIDEBOOK ON WIND ENERGY CONVERSION APPLICATIONS IN HAWAII," DEC 82.
HANALEI
WIND POWER CLASS / MAX POWER DENSITY WATTS/M² / MEAN SPEED, MPH AT 10 METERS
1 100 9.0
2 149 11.5
3 189 12.5
4 249 13.4
5 299 14.3
6 399 15.7
7 1000 21.1
KAWAIHAU
WAIMEA
US WEATHER STATION
LIHUE
PRIVATE WECS
0 2 4 6 8
SCALE IN MILES
LEGEND:
STREAM
SWAMP
POPULATED AREA
JUDICIAL DISTRICT BOUNDARY AND NAME
PRINCIPAL ROADS & ROUTE NO.
WIND POWER CLASS BOUNDARY & NO.
WIND POWER CLASS 6 AREA
KOLOA
POIPU
WIND ENERGY MAP
KAUAI

Figure G-6

kilowatt of installed capacity. In terms of location, the Kahuku site is the only in the State suitable for large wind turbines (equal or greater than one megawatt, each).[10]

The only commerical WECS installation on the island of Kauai is a 10 kilowatt Jacos unit located at the Dairy Queen, Eleele. The wind power plant completed in July 1982, has averaged 57 kwh per day or at least 24 percent plant factor. The actual installed unit cost was $3,800 per kilowatt.[11] There are no other wind power plants on Kauai under construction or in known planning stages.

Among the wind turbines on the market, only a few equal or exceed 100 kilowatts in capacity. In fact, among 85 models identified by the State of Hawaii as commercially available, only five models are 0.1 MW or greater in capacity.[12] The turbine for the Kahuku Windfarm previously described has not been selected because of performance problems. The state-of-the-art does not appear to be yet at the stage for practical large scale utility application.

Finally, the implementation of WECS is extremely dependent on continuation of government incentives. Currently 35 percent of the cost can be written off as tax credits (15 percent Federal alternate energy

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[10]Personal communication with Mr. Thomas Morton, Project Manager, Wind Farms, Ltd. April 1983.

[11]Personal communication with Mr. Doug Carvalho, Manager, Dairy Queen, April 1983.

[12]Hawaii Natural Energy Institute, University of Hawaii. Guidebook on Wind Energy Conversion Applications in Hawaii. 2d Ed. Dec. 1982.

credit, 10 percent State alternate energy credit, 10 percent capital investment tax credit).[12] The individual investor obviously considers these credit essential for project's financial feasibility. The Federal tax credits were allowed to terminate on the scheduled expiration date of December 1985 and the planning and implementation of WECS was adversely affected.

Based upon the above, wind power plants on Kauai will not be significant for the utility system nor would not be implemented on a wide scale in the near future. In comparison to other islands in the State, Kauai has relatively low wind potential. Investors and businessmen would naturally look to other places before considering Kauai (such as Kahuku on Oahu, east Molokai, and Kohala/Waimea on Hawaii). The turbo-generator hardware has not been sufficiently developed for practicial electrical utility application. With large units, performance becomes critical and is compounded by potential problems in construction and maintenance. The cost also appears relatively high compared to hydropower systems. Excluding government credits, the current range of cost appears to be $3,000 to $4,000 per installed kilowatt of capacity, well above the unit cost of a hydropower plant. The loss of tax credits also casts a cloud on future implementation. As a result of these findings, the wind power plant was not considered for further evaluation.

<u>Hydropower Retrofitting and Development at Existing Dam Sites.</u> In Kauai, similar to other areas of the United States, there exists a significant number of non-Federal dams being subject to evaluation in accordance to the National Program for Inspection of Dams (Public Law

92-367). The program investigated dams 25 feet or more in height or dams with impoundment capacity of 50 acre-feet or more. A total of 52 dams were categorized for Kauai, all which are either currently or were historically used by the sugar industry for irrigation. All dams are of the earth-fill type and all except five were constructed during the period 1890 to 1932.

Among the Kauai dams, Alexander Dam, located on the Wahiawa Stream in the Koloa district, is the only facility with a hydropower plant. The dam, under the ownership of McBryde Sugar Company, is an earthfill structure with a height of 119 feet and a reservoir maximum capacity of 2,500 acre-feet. The power plant is located approximately 8,000 feet downstream of the dam. Water is conveyed via open channel through a forebay and down a 5,000-foot, 30-inch steel penstock.[13] The installed capacity is 1.0 MW and the average annual energy produced is 2.1 million kwh. The parent company of McBryde Sugar, Alexander and Baldwin, indicates there are no major plans for major retrofittng at the existing Alexander Dam.

Under the Corps' National Hydropower Study conducted during the period 1978-1980, the analysis of Kauai sites revealed only one other existing dam site which had hydropower potential. The Koloko Reservoir located on a ditch near Kilauea, Kauai, was formerly an irrigation facility of the defunct incrementally too small for an effective powerplant.

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[13]U.S. Army Corps of Engineers, Pacific Ocean Division. "Phase I Inspection Report on Alexander Dam" Honolulu: June 1978.

Finally, based upon the U.S. Department of Energy's Program Research and Development Announcements and Feasibility Study and Licensing Program the State of Hawaii Natural Energy Institute (HNEI) and the U.S. Department of Energy attempted to elicit responses from existing dam owners to apply for hydropower assistance. Material and coordination during the period December 1977 to June 1979 did not result in any application for assistance from any Kauai dam owner. As a result of the above findings, it appears that there exists no significant potential for retrofitting or developing incremental hydropower of existing dam sites in Kauai. This potential solution was not considered for further evaluation.

New Conduit Hydropower Diversion and Power Plant. Stemming from renewed interest in hydropower since 1977 various Federal agencies have implemented combinations of studies, grants, new regulations, technical documents, and demonstration projects which address small scale hydropower facilities, in general, the advantages of conduit systems as compared to other energy technologies are:

a. Less massive physical modification and disturbance to natural conditions.

b. Minimal utilization of prime lands available for industry, agriculture, or urban development.

c. Less initial capital expenditures than large hydropower or new thermal plants.

d. Minimal development or technological advances required.

e. Institutional frameworks already established for governmental review and evaluation processes.

For these reasons, the new conduit hydropower diversion and power plant has the best potential for possible solutions.

New Dam/Reservoir and Hydropower Plant. A dam and reservoir system consists of a dam to store water, outlet structures to regulate flow, and power plant. The power plant may be located at the base of the dam or further downstream to obtain the necessary head. Power generated by a dam and reservoir syatem is generally dependable provided there is sufficient reservoir storage capacity. Storage type hydropower facilities have been previously proposed for Kauai for the Kokee (1964) and Waialeale (1978) studies. Both facilities although based on multipurpose benefit evaluation, were too financially clostly, and due to insuffient head, both facilities also required very long penstock to develop the power. The Waialeale project was estimated to cost $72 million (1978 prices).

For Kauai and the Hawaiian Islands in general, erosion has changed the topography of the islands from huge gently sloping volcanoes to dissected adn incisioned cliffs, valleys and basins. The topography of many of the drainage areas is characterized by relatively steep stream courses and steep, rugged basaltic formations. As a result, the streams generally do not meander and traverse through alluvial areas. Characteristic of

Hawaiian topography impoundment of significant volumes for stable hydropower releases would require very massive dam structures. Combined with relatively low rates of streamflow, the generalized conclusion is that dam and reservoir projects would be very difficult to economically justify and finance. For these reasons, this potential solution was not considered for further evaluation.

ALTERNATIVES TO BE CONSIDERED

The analysis of generalized alternatives indicated potential solutions worthy of further consideration are conservation/solar not water heating and conduit hydropower. Each of these alternatives would provide contributions to meet the energy demands of the island. The quantitative contributions to the national objectives are the subject of the detailed evaluation and are contained in the following report section.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

ISLAND OF KAUAI SITES

Identification of Sites. The island of Kauai, as explained in prior sections, constitutes a single electrical utility area. Hence, to contribute to energy development, it was necessary to consider hydropower development on an islandwide basis. Among the 59 stream gage sites itemized under the statewide hydropower study, only a fraction has been considered or identified from various studies for hydropower improvements. Many of the high potential areas have previously been investigated or are currently under study. Other areas would be limited by significant environmental/social or institutional considerations.

An early hydropower report for the State of Hawaii was published by the Bureau of Power (currently the Federal Energy Regulatory Commission) in 1968. At that time, there were two potential sites identified, at Wainiha and at Kokee. Since the Arab oil embargo in 1974 and the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978, there has been a greater interest in the investigation of hydropower sites throughout the State.

By utilizing the U.S.G.S. flow data for Kauai, the Hanalei River at U.S.G.S. Station 16103000 has the most favorable flow conditions for hydroelectric development. Further the gradient of the stream is also very favorable for a project of this nature. As discussed in other sections, the environmental consequenses of this project would not be significant and existing uses of land and water would not be significantly affected. Therefore, the Hanalei River site was selected for the potential solution for future power generation.

NEW FORMULATION ANALYSIS

Based on fundamentals of hydropower development, the highest power potential results from harnessing the highest discharges at locations of steepest elevation change. A preliminary hydrographic analysis was conducted considering the relative effects of discharge and topographic relief. For purposes of preliminary sizing analysis of run-of-the-river or conduit sytems, a 20 percent value of the daily flow duration curve was selected as an appropriate discharge criterion. In addition, to provide a more flow for more production, flows from several tributaries were included within the project plan. The selected project area provides the largest elevation difference possible while allowing a relatively high flow discharge. Higher locations for the diversion would increase the elevation differential, but flows would decrease in a more significant proportion. Sites below the project area have a lower elevation differential without significant additional discharge. Hence, to take advantage of the maximum contributing drainage area and change in elevation the diversion structure was located near elevation 650 and the power plant near elevation 100.

INTAKE AND POWER PLANT SITING

Considering that the intake structure should be sited at the confluence of the Hanalei River and Kaapoko Stream, the power plant site was located as low as possible but without impacting the existing land use, diversions, or potential future use of the area. Although there are innumerable other potential combinations of intake and power plant locations, topographical analysis demonstrated that none would achieve a more desirable combination of flows and elevations.

ADDITIONAL DIVERSION

An additional consideration was the potential for increasing the available flow from the Hanalei River by utilizing several tributaries for power production. The tributaries with the most significant flows were generally included within the project plans. The additional discharge would result in increased power capacity and energy generation. However, consideration would be given to the potential additional costs for diverting and piping these flows and larger capacity of the conduit to accomodate large design flow, and finally, higher power plant costs for the additional power capacity.

"WITHOUT DIVERSION" ALTERNATIVES

The evaluation revealed that including the additional diversion would greatly enhance the net economic benefits. The additional cost of improving the diversion capability of the project would be more than offset by the benefits from the additional energy generated. Based upon these findings, the "without additional diversion alternatives" were not considered for further evaluation.

CAPACITY SCOPING

As the power plant size required scoping, due to the physical constraints, the head was relatively constant but the design discharge was the key variable. The civil works facilities (diversion structure, conduit, and penstock) were relatively fixed, escalating mildly as a function of increased discharge. The power plant costs (turbine-generators, electrical works) also varied with increased discharge. The civil and power plant costs were combined to obtain a total project cost and was essentially a function of the discharge.

Characteristically of conduit hydropower facilities (where no storage is available), the optimization of plant capacities requires maximum utilization of available discharges, graphically shown on flow duration curves. The actual computational process utilized a variant of the flow duration curve, the power duration curve, essentially a cumulative frequency curve of power as function of percent of occurence. The results showed that the costs were a linear function of capacity and the benefits curvilinear, after achieving a peak value. Based upon the differences between the two functions, the plant capacities were selected.

SINGLE TURBINE/DOUBLE TURBINE

In a similar analysis, the relatively steep descent of the flow duration curve severely limited the effectiveness in a single sized turbine unit. In general, turbines can operate over a limited range of discharges. A single turbine would not effectively capture all flows for streams exhibiting steep flow duration curves. Hence, a single turbine-generator unit would incur relatively high initial power plant costs and would forego generating energy from either high or low discharges. In contrast, the two turbine concept although more costly, would capture a wider range of flows and would develop correspondingly greater amounts of energy, hence, the single turbine concept was not considered for further evaluation.

SELECTED PLAN

The project would consist of the basic hydropower features of hydraulic control and penstock structures, power plant, transmission line, and access facilities.

The improvements would include the principal water transmission and power development features. The concrete diversion weir located approximately 11.1 river miles upstream from the mouth would be 10 feet high and have a crest length of 75 feet. The ponded water would flood less than 1 acre upstream of the weir to an elevation of 650 feet msl. An intake structure adjacent to the dam would be connected to the penstock which varies in size from 54" to 72" is 23,325 feet long. Several tributaries will also be diverted for power production. A minimum conservation flow of 10 cfs would be maintained for the river. The penstock would be constructed by above ground methods and cut-and-cover methods would be used at river crossings.

The lower end of the 72" penstock would be bifurcate into 48" turbine feed pipes. The powerhouse located approximately 6.2 river miles upstream from the mouth. The powerhouse would contain 2 turbine-generators with a total capacity of 8 MW developing an average of 29.5 million kwh of energy annually. The plant will not be operative during periods of low flow and as a result no firm capacity can be provided to the existing utility system. Access to the powerhouse will be provided by a new access road and approximately 0.6 miles of new 69 kv transmission line would interconnect the project to Kauai Electric's system.

PLAN ACCOMPLISHMENTS

The selected plan would provide an additional source of energy for the island of Kauai, effectively utilizing the available upper Hanalei River flows. The benefits are derived from the displacement of energy to Kauai Electric's system. Since the facility is a conduit hydropower plant with no effective storage capability, no capacity credit will be provided for the benefit evaluation.

The existing electrical utility system is highly dependent on fuel and diesel oils (60 percent as of 1981) for electrical generation. Although according to latest demand projection; the local utility company has sufficient reserve capacity, its capability is limited when its major purchased capacity is shutdown. Any additional capacity, especially from non-fossil fuel generated sources would be beneficial.

The proposed facility would not conflict with the operation of any existing water resource facility. The irrigation systems upstream and downstream would continue to be operative with existing diversions. There are no authorized nor constructed Federal dam or hydropower facilities on the island. In addition, there are no existing permits or licenses issued by FERC for potential hydropower facilities in the area.

The selected plan addresses the major study problems previously discussed. The plan if constructed would decrease the dependence of the island of Kauai on petroleum-based fuels and would add to its energy self sufficiency goal. Based on current fuel oil utilization rate, the plan would displace the need to import approximately 60,000 barrels of oil annually. The plan would add to the energy supply of the local utility and would provide the equivalent energy service to approximately 5,500 households on the island.

H. THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

AFFECTS AND USES AND PRODUCTIVITY

The proposed Hanalei River Hydroelectric project will cause a number of impacts to the immediate project area. However, the majority of these impacts are construction-related and are short term in nature. The reduction of flows in the Upper Hanalei River will remain the most significant impact to the area. This impact will be long term in nature. The project will not affect current downstream uses of Hanalei River flows and will not cause long term significant impacts to downstream uses.

Future options for use of the water for power generation or for other uses will no longer be available between the diversion site and powerhouse locations. Any further uses that might be linked with the use of the flows will either be reduced or will no longer be available. Potential beneficial uses for these flows would be for agricultural uses. However, the majority of prime, unused agricultural land lies between existing uses and the powerhouse.

The options for additional hydroelectric power generation will not be available at this site since the proposed project will utilize the maximum amount of flow and power head potential in the project area.

No short term or long term risks to health or safety will be caused by the proposed project.

The majority of productivity in the Hanalei Valley is from the agricultural production of taro (approximately 3 river miles downstream from the powerhouse). Construction related impacts will not be significant and will be primarily from an increase in sedimentation in the river. These impacts will be short term and will not affect the productivity of these prime agricultural areas.

Other productive uses of lands downstream from the project are the wildlife refuge, scenic lookout and grazing. The proposed project should not create significant impacts to these productive uses.

I. MITIGATION MEASURES PROPOSED TO MINIMIZE IMPACT

IMPACT MITIGATION

Although most of the proposed project impacts cannot be avoided altogether, many can be reduced or minimized by prudent construction practices and timing of the construction phases.

By limiting movement of heavy construction equipment in the stream, removing dredged and excavated material from the stream channel, and scheduling construction activities in the water or along the channel banks and walls to the months of least rainfall (June-September), degradation of the stream habitat can be greatly reduced.

The following actions are proposed to mitigate the unavoidable short-term and long-term impacts which the proposed project will cause to the existing resources in the immediate project area.

IMPACT: Reduction of flow in the Hanalei River during periods of power production resulting in a reduction of aquatic habitat and flows.

MITIGATION: A minimum instream flow will bypass the proposed new diversion in the Hanalei River, to maintain the aquatic resources in the diversion reach.

A conservation flow for the river will be maintained. The conservation flow will be established to preserve the bilogical communities which currently inhabit the river in the proposed project area.

The design of the diversion dams will be constructed so that a wide shallow notch will release the conservation flow. Additionally, the downstream face of the diversion dam will be rock faced and constructed to facilitate upstream migration. The final design will be coordinated with the U.S.F.W.S. and the D.L.N.R., Division of Aquatic Resources.

A fish screen will be installed at each intake to help prevent fauna from entering the diversion pipelines and penstock and traveling down to the turbine.

IMPACT: Decreases in water quality and air quality due to construction related impacts.

MITIGATION: Precautions will be made to minimize the use of heavy construction machinery in the river channel. Measures will also be taken to prevent blockage of flows during placement of materials in the river channel. Precautions will be taken to minimize excessive dust from the construction area and the disposal of slash will be accomplished at a landfill to be determined by the State of Hawaii Department of Health.

IMPACT: The reduction of instream flows will reduce the available habitat for endangered Hawaiian water birds.

MITIGATION: A minimum instream flow will bypass the proposed new diversion in the Hanalei River, to maintain the aquatic resources in the diversion reach.

A conservation flow for the river will be maintained. The conservation flow will be established to preserve the bilogical communities which currently inhabit the river in the proposed project area.

IMPACT: The diversion impoundment may accumulate sediments deposited from construction and high intensity storm events.

MITIGATION: Periodic flushing will be made at the new diversion weir which will allow for passage of any sediments that have accumulated. Scheduling of flushing will be coordinated with the State of Hawaii Division of Aquatic Resources.

IMPACT: Mortality rates for adult native diadromass species may increase due to entrainment into the penstock and passage through the turbine units.

MITIGATION: Screening of the intake to the penstock will be incorporated to prevent or reduce entrainment. Screening design will be made in coordination with the State of Hawaii Division of Aquatic Resources and the U.S. Fish and Wildlife Service.

IMPACT: Potential impacts to unknown historical sites may occur as a result of constructing the project.

MITIGATION: Additional archeological studies will be conducted prior to construction of the project to identify any unknown historical sites. If any significant sites are thought to be impacted by the project, changes or modifications to the project alignment or locations of various components may be necessary. Upon discovery of bones, artifacts, or other significant findings construction work will be stopped immediately and the State Office of Historic Preservation notified.

IMPACT: Erosion and loss of topsoil may occur during construction of the project causing an increase in sedimentation to the Hanalei River and a decrease in productivity in the areas below the project.

MITIGATION: An erosion control plan has been formulated and will be utilized during construction of the project to prevent any significant erosion of soils or increases in sedimentation to the Hanalei River. Disturbed areas will be re-seeded as soon after construction as possible. Areas disturbed for construction of the project will be kept at a minimum. Temporary erosion control structures will be constructed to prevent additional sediments from reaching the river. Stockpiled soil will be kept covered as much as possible with mulch or other suitable materials to lessen erosion.

J. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

AFFECTED NON-RENEWABLE RESOURCES

The proposed project will make use of a limited amount of non-renewable resources, both during the construction and operation phases.

Non-renewable resources of wood, concrete and steel will be used in construction of the project. The loss of these resources, though insignificant will not be retrievable.

K AN INDICATION OF WHAT OTHER INTERESTS AND CONSIDERATIONS OF GOVERNMENTAL POLICIES ARE THOUGHT TO OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

ENERGY GOALS

The proposed project is a step toward fulfilling both National and State goals of developing renewable energy resources. This will help to alleviate the dependence upon foreign resources which will eventually help to reduce costs of electricity to the ratepayer and will help ensure a reliable source of power.

Since the project can be implemented without significant impacts to the environment and a need for the project exists, the benefits associated with the action would appear to offset the environmental impacts.

EFFECTS UPON TOURISM

The proposed project will not pose adverse impacts to the visual appeal of the Lower Hanalei Valley which is the primary attraction to tourists in the area. A minimum flow of 6,467,040 gallons per day will be maintained at all times during project operation to ensure the preservation of aquatic life and visual appeal of the Upper Hanalei River. The project is not expected to cause any significant impacts to the existing qualities for tourist attraction at this site.

At least two new major hotel developments are expected to be placed into service during the period of 1987-1989. The demand for increased electrical energy to meet the expected needs will rise sharply during this period. Kauai Electrical Division's base and peak load requirements will increase significantly. The proposed project will insure that a substantial power source will be available which is not dependent upon resources which are vulnerable to shortages or embargos. It is important to the tourism industry on the Island of Kauai that electrical power always be available for hotels and popular destinations to operate. The Hanalei River Hydroelectric Project will add to the energy self-sufficiency of the Island of Kauai and will help to reduce the long-term cost of electric energy which may indirectly benefit tourism.

L. ORGANIZATIONS AND PERSONS CONSULTED

LIST OF PREPARES

This statement was prepared in behalf of Island Power Company, Inc. (the "Applicant") by Bingham Engineering, 100 Lindbergh Plaza 2, 5160 Wiley Post Way, Salt Lake City, Utah 84116.

The following list identifies the personnel responsible for preparing the Draft Environmental Impact Statement and the Final Environmental Impact Statement.

NAME	EXPERIENCE	TITLE
Jay R. Bingham President Bingham Engineering	Civil Engineer Hydraulic Engineer	Engineering and Design of Civil and Hydraulic Works
Clark M. Mower Vice President Bingham Engineering	Civil Engineering Environmental and Ecological Specialist	Preparation of Environmental documents, principal agency coordination
Corbin A. Bennion Bingham Engineering	Civil Engineer Hydrologist	Sedimentation, Hydrology
Galen W. Williams Bingham Engineering	Geotechnical Engineering Hydrological Engineering	Geotechnical Engineering Erosion Control
E. Farley Eskelson Bingham Engineering	Civil Engineer Hydrological Engineering	Hydrological Studies and Flow Analysis
Judd R. Lawrence Bingham Engineering	Civil Engineer Hydraulic Engineering	Consulting for Civil and Hydraulic Works
Jack B. Matheson Bingham Engineering	Drafting and Technical Specialist	Design Drawings and Report Exhibits
Dan Matta Bingham Engineering	Landscaping Architecture and Design	Visual Analysis Exhibits
Jeff Burt President Island Power Company	Project Development	Project Director and Principal Developer
Mervyn Kimura Director Island Power Company	Project Management	Director of Island Operations

The following list identifies the project consultants responsible for the preparation of the reports contained in the Appendix to this document.

Dr. Amadeo Timbol - Stream Fauna
Kauai Community College
Island of Kauai, Hawaii 96766
4928 Eggerking Place
Kapaa, Hawaii 96746
(808) 245-8311 Kauai Community College
(808) 822-4534 Home

Dr. Andrew Berger - Birds & Mammals
1349 Kianui Drive
Kailua, Hawaii 96734
(808) 262-8325

Hallett Hammett - Archeology
Cultural Surveys Hawaii
49 South Kalaheo Avenue
Kailua, Hawaii 96734
(808) 262-0072 Office
(808) 261-8293 Home

Ms. Wynona Char
Botanical Resources
4471 Puu Panini Avenue
Honolulu, Hawaii 96816
(808) 548-7417 Office
(808) 734-7828 Home

The following lists the principle agency personnel involved in agency consultation and coordination.

Mr. Donald E. Heacock
Aquatic Biologist
Department of Land & Natural Resources
State of Hawaii
P O Box 1671
Lihue, Hawaii 96765
(808) 245-4444 Office

Mr. John I. Ford
Mr. Andy Yuen
U.S. Fish & Wildlife Service
Room 6307
Federal Building
300 Aloha Moana Boulevard
Honolulu, Hawaii
(808) 546-7530
(Jim Krakowski - Wetlands Coordinator)

James Pennaz, P.E.
U.S. Army Corps of Engineers
Pacific Ocean Division
Building T-1
Fort Shafer, Hawaii 96858
(808) 438-1907
(808) 438-1207

Mr. Ralph Daehler
District Forester
Department of Land & Natural Resources
State of Hawaii
P O Box 1671
Lihue, Hawaii 96765
(808) 245-4433 Office

Mr. Dan Moriarty
U.S. Fish & Wildlife Service
Kilauea Lighthouse
Kilauea, Hawaii
(808) 828-1243

John Emerson - PODCO-O
Mike Lee
U.S. Army Corps of Engineers
Building 230, Room 205
Fort Shafter, Hawaii 96858
(808) 438-9258

Avery H. Youn
Planning Director
Kauai County
4280 Rice Street
Lihue, Kauai, Hawaii
(808) 245-3919

Mr. Bill Blanchard
Kauai County
Department of Economic Development
Lihue, Kauai, Hawaii

In addition several individuals who have expressed concerns about the project have been consulted. Two public meetings have been held where the project was discussed.

M. REPRODUCTION OF COMMENTS AND RESPONSES MADE DURING THE CONSULTATION PROCESS

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY
BOARD OF LAND & NATURAL RESOURCES
LIBERT K. LANDGRAF
DEPUTY TO THE CHAIRMAN

DIVISIONS:
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AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

JAN 23 1987

FILE NO.: KA-9/11/86-1927
180-Day Exp. Date: 3/10/87
DOCUMENT NO.: 2380B

Mr. Jeff Burt, President
Island Power Company, Inc.
c/o Bingham Engineering
100 Lindsbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

SUBJECT: Request for Time Extension on the Conservation District Use Application for a 6.0 MW Hydroelectric Project with Accessory Uses Along the Hanalei River, at Hanalei, Kauai, Hawaii

Thank you for your letter of January 15, 1987 requesting a 90-day extension to the 180-day processing time on your subject application.

According to your information, you are currently preparing your Draft Environmental Impact Statement for the project. This process will extend beyond the current 180-day expiration date of March 10, 1987 on your application. Thus additional time to the CDUA processing time will be required.

After reviewing your request, and pursuant to Section 183-41 of the Hawaii Revised Statutes, as amended, we hereby grant your 90-day extension request. Be advised that the new expiration date for your application is June 8, 1987.

Should you have any further questions regarding this matter, please feel free to contact our Office of Conservation and Environmental Affairs in Honolulu, at (808) 548-7837.

Very truly yours,

WPaty

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

cc: OEQC
DAR/DOFAW/DOCARE/DOWALD/NARS
State Parks-Historic Sites/Land Management

Island Power Company, Inc.

January 15, 1987

Mr. Dean Uchida
State of Hawaii - DLNR
1151 Punchbowl Street
Room #130
Honolulu, Hawaii 96813

Re: CDUA permit for the Hanalei River Hydroelectric Project on Kauai, Hawaii.

Dear Dean:

As discussed in our telephone conversation today, we expect that our Draft Environmental Impact Statement for the above referenced project will be ready for submittal by February 5, 1987. In order to facilitate an adequate review of this proceeding, we request a 90 day extension be added to the 180 day deadline.

Your assistance in this matter will be greatly appreciated.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

Carol M. Wilcox

111 Royal Circle, Honolulu, Hawaii 96816

January 3, 1987

Clark Mower
Bingham Engineering
100 Lindbergh Place
SLC, Utah 84116

Dear Clark,

RE: Hanalei Hyrdrelectric Project

We too appreciated the chance to meet with you regarding the Hanalei Hydroelectric Project. By now you should have received the tape of our meeting, and included here is a copy of the base line study proposed by the Ad Hoc Committee for North Shore Recreational Water Use Management Plan, as you requested. We expanded this proposal to include the Wainiha River, specifically to include a North Shore river with a hydroelectric. This is no guarantee that this will be the scope of the final baseline study, of course.

I am also including some information regarding Hawaii's river and streams. It deals primarily with environmental concerns, but that is not to be interpreted as a lack of concern for the economic, aesthetic and recreational issues. This is a complicated subject, one that we are just familarizing ourselves with.

Since we talked, we have organized ourselves as Wai 'Ola, which means Living Waters. Our goals will be to discourage any development that would impact our North Shore rivers until baseline studies and a statewide river inventory are completed. We are initiating these processes, and feel confident that they will be underway in 1987.

I want to be candid with you. Our information, even as scanty as it is, points to the need to proceed very slowly and carefully as far as the Hanalei River goes. In fact, studies may determine that a hydroelectric facility on this particular river is not desirable. As visitors to our islands, Bingham Engineering may not be aware of the importance of Hanalei and the North Shore of Kauai for values other then energy sources. It is the responsibility of both the community and our local government, and our State law, to "...avoid permanent losses of valuable resources and the foreclosure of management options,..." (HRS 205A-21) We propose to insure that this happens.

Bingham Engineering and Wai 'Ola can choose to proceed in one of two ways, co-operatively or antagonistically. Having experience on both approaches, I want you to know that I far prefer the former. It is more effective and less aging and less expensive in many other ways of reckoning. It was my impression, from our conversation of 12/5/86, that you agree.

This requires a certain amount of communications and trust be established between us. The goal would be clarity.

For instance, what we need now is time. Time to initiate and see the studies and inventory mentioned earlier underway. In our discussion, you acknowledged the reasonableness of that request, and felt that BE could accomodate it. AFter your discussion with the home office, is this still true?

Looking forward to hearing from you.

Sincerely,

Carol Wilcox

Carol M. Wilcox

PROPOSAL FOR A BASE LINE STUDY OF THE
HANALEI RIVER ESTUARY

I. BACKGROUND
II. PURPOSE/GOALS/QUESTIONS
III. APPROACH
IV. IMPLEMENTATION

BACKGROUND

The environmental and scenic importance of rivers and estuaries is being increasingly recognized in America, as demonstrated by the Federal Wild and Scenic Rivers Act (Public L-aw 88-29 and Public Law 90-542). Hawaii is one of a handful of states that has not yet initiated an inventory of its rivers pursuant to that Act. Of Hawaii's many river estuaries, only a few remain in a natural state. A number of these are located on Kauai's North Shoee.

Hawaii's estauries are unique, with ecosystems to be found no-where else in the world. These systems are small by world standards, however, "These estuaries are important, nonetheless. Because these features are small, they are particularly vulnerable when subjected even to relatively minor environmental insults." (Estuarine Pollution Control and Assessment, ~~1977,~~ Stephen V. Smith, 1977, p 297) And further, "Despite their small size, Hawaiian estuaries generally flush rather slowly,.... These relatively long residence times for estuarine waters and their included pollutants have obvious implications for the biota of Hawaiian estuaries and emphasize the importance of intelligent, informed estuary management." (ibid, p 300)

Equally needed is an improved data base describing the Hawaiian estuaries. In particular, there appears to be a lack of foresight in obtaining baseline data before any projected environmental alteration---whether that alteration is predicted to be good, bad or benign---or to combine that data with post-alteration descriptions, in order to describe the biotic responses to that alteriation. (ibid, p 303)

In attempting to get a response from our local oceanic management experts, the AdHoc Committee finds that without base line data no one is able to answer our questions with any authority regarding the environmental impact of commercial boat operations and/or dredging of the river mouth and/or a marina to the Hanalei River and Bay.

As the;
1. awareness of the importance of rivers and estuaries grows
2. the pressures and "insults" to our remaining natural estuaries increase.
3. need for baseline data in Hawaii has been identified.
4. Hanalei River has been identified in a State survey as exhibiting more "outstanding remarkable values" than any other river in the State.
5. Hanalei River estuary, in that same survey, has been identified as possesing""outstanding fishery values."

6. Pressure grows to use and develop the Hanalei River estuary for commercial boat operations.

...it seems imperative that a base line study of the Hanalei River Estuary be initiated As Soon As Possible.

II PURPOSES/GOALS/QUESTIONS

1. To establish base line data on the biota of a Hawaiian estuary system
2. To establish base line data on the fish "nursery" function of the Hanalei River Estuary (HRE)
3. To provide water quality analysis
4. To determine water flow patterns in HRE and the immediate environs.
5. Knowing that dredging of the summer sand berm has been suggested, establish the importance of said berm to the HRE ecosystem.
6. Knowing that use of the HRE for commercial boat operations has been suggested, establish if possible the impact of such operations. Particular attention to the concerns expressed of petrochemical pollution and its impact.
7. Knowing that Puupoa has been suggested as preferred staging site for commercial boat operatins, evaluate impact of such location on the Hanalei River Estuary.

III APPROACH

Lumahai, Hanalei and Wailua Rivers to be observed over a period of one year. This will provide a comparison among three Kauai rivers, all within the same time frame, over a complete cycle of seasons, and will provide information from rivers that cover a wide spectrum of pristineness. (State survey comments that Lumahai river "terminates in the most pristine estuary in the State.)

Observation to include regular collection or observation (weekly, bi-weekly?) of data needed to help answer above concerns, which data may include the following;

1. water samples from river and estuary
2. sub-strata samples
3. Limu and/or plankton samples
4. Observations/collection of "Indicator species"
5. Biota observation

Analysis of samples, such as water and sub-strata sands.

Collation of information with report of conclusions and implications no later than ____________. (date)

IV IMPLEMENTATION

It is our understanding the the facilities and capability for analysing the samples exist in Honolulu, be they U.H., State of Hawaii, or military facilities, and should be available without burdensome expense.

One problem seems to be manpower to collect the samples. Personnel in the DLNR, Dept of Health, Oceanic Resources, etc,. are already stretched. A solution may be hiring local fishermen, naturalists, or Kauai Eommunity College studfents, to collect samples. The AdHoc Committee would be glad to assist identifying such people.

Sea Grant is
~~You are~~ probably aware of which individual, organization or institution could best complile this information and write up the conclusins. Besides looking for competency, the next most important factor is Time. As they say in real estate contracts, Time Is Of the Essesnce, and should be a part of any agreement regarding the Hanalei River Estuary Base Line Study.

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
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AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

DEC 10 1986

FILE NO.: KA-1927
DOC. NO.: 2051B

Mr. Clark M. Mower, Vice President
Bingham Engineering
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Mower:

SUBJECT: Conservation District Use Application No. KA-1927 for a 6.0 MW Hydroelectric Project at Hanalei, Kauai

Thank you for your letter of November 11, 1986 requesting copies of testimony presented at the public hearing held on November 6, 1986.

Enclosed you'll find all testimony received to date on your application. We suggest that you discuss/address the various concerns raised as a part of the Environmental Impact Statement (EIS) process.

As was discussed with you at your December 2, 1986 meeting with our staff, there will be a fee of .50¢ per page assessed for copies of the testimony submitted at the public hearing. Therefore, please remit cash or a check payable to the State of Hawaii for $8.50 (17 pages @ .50¢/page) covering the copies provided.

Please keep us apprised of your schedule for filing your draft EIS. Should you have any questions, feel free to contact Dean Uchida of our Office of Conservation and Environmental Affairs in Honolulu at (808) 548-7837.

Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

Attachments

Island
Power
Company,
Inc.

January 26, 1987

Mr. Gary L. Blaich, M.D.
President
1000 Friends of Kauai
Box 404
Kilauea, Kauai, Hawaii 96754

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Dr. Blaich:

This acknowledges receipt of a copy of your letter dated November 19, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that the DEIS include an IFIM Study and an adequate assessment of the proposed project's effect on the Hanalei Estuary. You also wish to have another public meeting after the EIS has been completed.

The DEIS will include an adequate assessment of the projects effects to the Hanalei Estuary, however, the IFIM study will not be included within the DEIS.

Island Power believes that the IFIM is unproven in the Hawaiian Islands and adequate baseline data is not available. Inclusion of this study in the DEIS could cause confusion and controversy. Further, more than adequate flow data exists to determine a minimum by-pass flow for the CDUA process. Island Power believes that the IFIM study should be performed as a condition of the CDUA permit prior to construction. If the data generated from the IFIM is determined accurate and useful, it could then be used to assess the adequacy of the minimum flow specified in the CDUA permit and if modifications are needed. Island Power believes that a transition such as this is necessary to introduce the IFIM study into the CDUA permit process.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

It is our understanding that another public meeting will be held after the final EIS has been submitted.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

15

GARY L. BLAICH, M.D.
Box 404
Kilauea, Kauai, Hawaii 96754
Practice Limited to Psychiatry

RECEIVED '86 NOV 20 PM 4:18 OCEA

RECEIVED 86 NOV 20 PM 4:10 DEPT. OF LAND & NATURAL RESOURCES STATE OF HAWAII OCEA

November 19, 1986

Mr. Susumu Ono
Chairman, Board of Land &
Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Re: Hydroelectric Plant
Hanalei River

Dear Mr. Ono:

On behalf of 1000 Friends of Kauai I ask that a decision on the hydroelectric plant on Hanalei River be postponed until a thorough EIS is done and completely reviewed by all interested parties. We agree with Mr. Ernie Kosaka, project leader of the U.S. Fish & Wildlife Services' Environmental Services section, that an EIS won't give enough information for important decisions unless it includes: 1. analysis of Hanalei River by the recently developed Instream Flow Incremental methodology (see enclosed article), 2. A good assessment of the proposed plant's effect on the Hanalei estuary.

Once the EIS has been distributed and adequate time provided for its review, we hereby ask that another public hearing be held so the proposal can be evaluated in light of the new information generated by the EIS.

With warmest regards,

Gary Blaich

Gary L. Blaich, M.D.
President
1000 Friends of Kauai

GLB:sjh

P.S. Thank you again for 11/14/86 public hearing on Na Pali helicopter landings. That was a good, spirited turnout.

Island
Power
Company,
Inc.

January 21, 1987

Honorable Peter K. Apo
Representative, 49th District
State Capitol
Honolulu, Hawaii 96813

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Representative Apo:

This acknowledges receipt of a copy of your letter dated November 17, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

No changes or additional information will be added to the DEIS as a result of your comments.

We understand that a public meeting will be held after the EIS process has been completed.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii. 96741

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DIV. OF LAND & NATURAL RESOURCES STATE OF HAWAII

OCEA

HOUSE OF REPRESENTATIVES

STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

November 17, 1986

Mr. Susumu Ono
Chairman of the Board
Board of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Subject: Hydro-Electric Proposal for Hanalei River

Dear ~~Mr. Ono~~ Sus:

Just a short note to express my concern that as the Hydro-Electric proposal is subjected to further review and processing that we include a post-EIS public hearing on Kauai. I realize that we are not required to hold such a hearing but I believe it would be prudent for us to do so.

I appreciate your attention to the need for a public hearing at the appropriate time and in response to the forthcoming EIS. If you have alternative suggestions as to how we might provide the public with a formal opportunity to express their views short of a public hearing please let me know.

~~Aloha pumehana,~~

Peter

Peter K. Apo
Representative, 49th District

PKA/me

January 26, 1987

Island
Power
Company,
Inc.

Mr. Ralston H. Nagata, Administrator
State of Hawaii - DLNR
Division of State Parks
P.O. Box 621
Honolulu, Hawaii 96809

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Nagata:

This acknowledges receipt of a copy of your letter dated November 13, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that the applicant provide a complete inventory of historic sites in project areas along with an assessment of each sites significance and indentification of significant sites, clear impact assessment and appropriate mitigation and adverse impacts on significant sites.

During this past summer, Mr. Hallett Hammett conducted an archeological survey of the project area for Island Power and identified all of the sites which were found. The DEIS will include the results of this survey along with the recommendations for mitigation measures to avoid or minimize impacts to historic sites in the project area. As a result of these findings, the project will not pose significant impacts to the historic sites in the Hanalei Valley.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo, Kauai
Hawaii. 96741

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

RECEIVED

'86 NOV 17 AM 8:38

OCEA

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF STATE PARKS
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

November 13, 1986

1

MEMORANDUM

TO: Roger Evans, OCEA

FROM: Ralston H. Nagata, State Parks Administrator

SUBJECT: Comments on CDUA KA-1927 -- Hanalei Hydroelectric Project
Hanalei, Hanalei, Kauai
TMK: 5-4-1: 1; 5-4-2: 2; 5-3-1: 3

Please see our previous comments on the CDUA application sent to your office July 21, 1986 (attached). These comments are still applicable.

RALSTON H. NAGATA

Attachment

ATTACHMENT

July 21, 1986

MEMORANDUM

TO: Roger Evans, OCEA

FROM: Ralston H. Nagata, State Parks Administrator

SUBJECT: Application for Proposed Use of State-Owned Conservation District Lands, Review for Chairperson's Signature -- Hanalei Hydroelectric Project (KA-1927) Hanalei, Hanalei, Kauai
TMK: 5-4-1: 1; 5-4-2: 2

HISTORIC SITES SECTION CONCERNS:

This project will involve ground disturbing activities in pipeline/road corridors and at small diversion weirs in the upper Hanalei valley, at a powerhouse in the mid-valley, and in a transmission line corridor in the lower valley.

We have concerns about this project. In reviews, our program looks for (1) a complete inventory of historic sites in project areas, (2) assessment of each site's significance and identification of significant sites, (3) clear impact assessment, and (4) appropriate mitigation of adverse impacts on significant sites.

We are concerned that the critical initial aim of complete inventory may not yet be adequately covered in this project. The EA states that a 2-day archaeological reconnaissance survey found no sites in the project areas (C-6). The reconnaissance report is not appended, and we have yet to see it; but these results do not meet expectations.

Known archaeological patterns and expected patterns are as follows: Most archaeological work in Hanalei valley has been in the lower valley, with surveys on the valley floor and the base of the eastern ridge up to 2.4 miles inland. Here the valley floor is covered in irrigated taro systems, with house sites and dry agricultural terraces on the base of the valley ridges (Schilt 1980). In the upper valley, 4 sites were minimally inventoried in 1930 by the Bishop Museum (Bennett

1931:133-4). These sites consisted of a heiau, houses and agricultural terraces on both sides of the stream at two points -- roughly where the intake structure is found and at the "River Mi. 7" mark on the EA's Figure N-3. This matches common archaeological patterns in upper valleys in Hawaii, and it is expected that other alluvial flats in Hanalei's upper valley may contain irrigated taro terraces and that the dry land at the base of the adjacent ridges contain houses, dryland agricultural terraces and occasional religious structures.

Given these expectations, we will not recommend approval of this CDUA until we can carefully review the reconnaissance survey report and until we are sure an adequate inventory survey has occurred. The EA does state that a comprehensive archaeological and historical inventory is planned for this summer (p. C-6), so perhaps the problem has been recognized and is being rectified. If so, we will still need to review the comprehensive archaeological report.

RECREATION CONCERNS:

There are no known public park interests involved.

/s/ RALSTON H. NAGATA

RALSTON H. NAGATA

RC:lt

January 26, 1987

Island
Power
Company,
Inc.

Mr. Jack K. Suwa - Chairperson
Board of Agriculture
1428 South King Street
Honolulu, Hawaii 96814-2512

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Suwa:

This acknowledges receipt of a copy of your letter dated November 10, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that the proposed project will create impacts detrimental to agriculture, principally with existing and possible future taro production in the Hanalei Valley.

The DEIS will specifically address all of the potential impacts to existing and possible future agricultural uses in the Hanalei Valley.

There have been several changes to the project since the original application for the CDUA permit. The most significant of these changes is the ommission of the permanent access road along the penstock route. A permanent access road will be used only to gain access to the powerhouse site. This will significantly reduce the amount of sedimentation into the river channel during construction and operation of the project.

The use of slope stabilization and revegetation will further minimize the amount of impacts caused by sedimentation.

The powerhouse is located at least one river mile upstream from the existing diversions for irrigation to the taro fields. This will allow all of the flows diverted for power production to return into the natural river channel well upstream from the existing uses of the water in the Hanalei River.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

The applicant does not expect the project to have any significant impacts to the agricultural uses in the Hanalei Valley. The statements made on Page D-2 in the Environmental Assessment were merely to point out that in the unlikely event of any unexpected impacts to agriculture, the developer would make compensation for the losses. This statement will not be used in the DEIS since these impacts are not expected.

Reference to the use of water which arises on the land located in TMK 5-04-2:3 was incorrectly made in the Environmental Assessment as the entire project will be located in TMK 5-04-1:1.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

GEORGE R. ARIYOSHI
GOVERNOR

JACK K. SUWA
CHAIRPERSON, BOARD OF AGRICULTURE

SUZANNE D. PETERSON
DEPUTY TO THE CHAIRPERSON

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814-2512

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96822-0159

November 10, 1986

MEMORANDUM

To: Mr. Susumu Ono, Chairperson
Board of Land and Natural Resources

Subject: Conservation District Use Application
6.0 MW Hydroelectric Project with Accessory Uses
Island Power Company, Inc.
TMK: 5-4-1: 1; 5-4-2: 2; and 5-3-1: 3
Hanalei River, Hanalei, Kauai
File No.: KA-9/11/86-1927
Area: 77.5 acres

The Department of Agriculture has reviewed the subject application and offers the following comments.

According to the application (page D-1), the proposed hydroelectric project would divert water from the Hanalei River through a 26,600 foot penstock. Additional water would be diverted from several of the larger tributaries to the Hanalei River on its westerly side. The amount of flow to be bypassed is currently being determined by the U.S. Fish and Wildlife Service and Division of Aquatic Resources, Department of Land and Natural Resources. A new 12-foot wide access road will also be constructed along the penstock route (page B-1).

The entire project is located within the State Conservation District, although an extensive area downstream from the project is within the Agricultural District. The Hanalei River Valley north of the "River Mile #7", shown on Figure N-3 of the application, is comprised of "Prime" and "Other Important" agricultural lands as classified by the Agricultural Lands of Importance to the State of Hawaii (ALISH) system. Other areas further downstream are classified as "Unique" by this method.

AGRICULTURAL SIGNIFICANCE OF AFFECTED LANDS

Our principal concern about the proposed project is its impact upon the existing and potential agricultural activities (especially taro) and resources of Hanalei Valley. "The island of Kauai is the center of taro production in the State with 68.94 percent (4.35 million pounds) of the State's total production in 1984" (Taro Industry Analysis Number 3, as approved by the Governor's Agriculture Coordinating Committee; April 23, 1986, page 1). The Analysis also states that the Hanalei Valley is the most productive taro growing area on Kauai. Taro growth requires 5,400 gallons of water per acre per day, plus additional water to cool the paddy (Taro Industry Analysis Number 3, page 4). Taro growth is said to be adversely affected by water turbidity and sedimentation. Construction associated with the project would appear to be a source of runoff.

On page A-1, the application states that "The applicant will also utilize water which arises on the land (TMK 5-4-1: 1 and 5-4-2: 3) ..., for the purpose of generating electricity." It is not clear whether this statement refers to an on-site spring and/or possible inundation from water constrained by the diversion weir. In either case, it is not indicated how these lands are currently utilized and whether inundation will adversely affect any agricultural activity on lands adjacent to and downstream of the proposed project.

Another statement on page D-2 refers to "agricultural damages" as a part of the $15 million project development cost. The type(s) of agricultural activity(ies) to be affected and the specific itemization of these "agricultural damages" are not provided, nor is there included an analysis of long-term impacts which may result, such as lost agricultural production.

To further expand taro production and acreage available for wildlife habitat in Hanalei Valley, the Fish and Wildlife Service of the U.S. Department of Interior spent $1.5 million for improvements to the water distribution system in the Valley (News Release, Governor's Office; No. 82-161, July 27, 1982). This project would have permitted an increase in taro acreage in the State by as much as 125 acres.

The new access road proposed for construction along the penstock route could also create impacts detrimental to agriculture, if design and location considerations do not include agricultural impact relative to construction runoff, drainage and grading.

In summary, the following items should be addressed and mitigative measures proposed by the applicant:

- The application should address in detail all impacts that the proposed project may have on the existing taro growing lands and the mitigative measures to be taken.

- If agricultural production in the area is adversely affected as a result of reduced flows from the proposed project, will compensation be forthcoming to the affected farmers?

- What measures are to be taken to avoid curtailing the potential expansion of taro production lands in the Hanalei area?

- What measures will be taken to control construction-related water turbidity and sedimentation that may adversely affect taro production during construction?

- Are there any agricultural activities between the diversion weir and the penstock that are currently dependent on streamflow for irrigation?

- Will the proposed access road adversely affect any streamside agricultural activities?

- Where are the lands located that are subject to periodic or permanent inundation, and what is the acreage involved?

- What are the agricultural damages referred to on page D-2, what mitigating actions are available to lessen these damages, and what are the ramifications for future agricultural production in the affected area?

Thank you for the opportunity to comment.

Jack K. Suwa
JACK K. SUWA
Chairperson, Board of Agriculture

cc: U.S. Fish and Wildlife Service (Honolulu)
Kauai County Planning Department
OEQC
DOWALD

SIGN UP SHEET
FOR THOSE WISHING TO TESTIFY ON
Conservation Distric Use Application
KA-1927

PLEASE PRINT LEGIBLY
IF YOUR NAME CAN NOT BE READ, YOU WILL NOT BE CALLED

NO.	NAME	ORGANIZATION REPRESENTING	TESTIFYING FOR	TESTIFYING AGAINST
1.	Clark Mower	Island Power - Bingham Forge	✓	
2.	TOM O'BRIEN	OPED	✓	
3.	CARL WILCOX	Ahimsa		✓
4.	" "	self		
5.	PETER [illegible]	STATE REP.		
6.	Hermina Morita	Resident Hanalei Valley		≠
7.	Kelvin Kai	Kauai [illegible]		
8.	KAIPO ASING	SELF.		
9.	BERT LYON	SIERRA CLUB		✓
10.	Deborah Spence	for Bill Mowry		✓
11.	ALFRED MAKANANI	KAUAI HOALA KANAWAI		✓
12.		ANAHOLA DEVELOPMENT PLAN COMM.		
13.	MELL N. NAPALES	SELF		✓
14.	[illegible]	Museum	✓	
15.	James Lyon	Kauai [illegible]		✓
16.	Sue Bunyan	self		
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

OCT 0 9 1986

FILE NO.: KA-9/11/86-1927
DOCUMENT NO.: 1822B

CERTIFIED MAIL

Mr. Jeff Burt, President
Island Power Company, Inc.
c/o Bingham Engineering
100 Lindsbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

SUBJECT: Conservation District Use Application for a 6.0 MW Hydroelectric Project with Accessory Uses Along the Hanalei River, at Hanalei, Kauai, Hawaii

A Board meeting for the purpose of a Public Hearing to receive testimony on the subject application has been authorized.

The Public Hearing will be held on Thursday, November 6, 1986 to receive testimony on the subject application. Details of this meeting are included in the attached copy of the published notice.

We would appreciate having either you or a representative present at the meeting to give testimony on your application. If you wish, photographs, plans, or other material may be presented to the Board at that time.

If there have been any changes or additional information to your application, please notify us as soon as possible.

Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

Attachment

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

NOTICE OF BOARD MEETING FOR PUBLIC HEARING
ON COMMERCIAL/CONDITIONAL USE WITHIN THE CONSERVATION DISTRICT

Pursuant to Section 183-41, HRS, and Title 13, Chapter 2, Administrative Rules, as amended, the Board of Land and Natural Resources, State of Hawaii, will hold a Board meeting for the purpose of a public hearing beginning at 6:00 p.m. or soon thereafter on November 6, 1986 in the Conference Room, 2nd Floor of the State Building at Lihue, Kauai, Hawaii to receive testimony on the following:

1. Conservation District Use Application No. KA-11/9/81-1380A filed by DLNR Division of Land Management for a subdivision for commercial agriculture on TMK: 1-2-02: 40 at Kekaha, Kauai, Hawaii.

2. Conservation District Use Application No. KA-9/11/86-1927 filed by Mr. Jeff Burt, President of Island Power Company, Inc. for a 6.0 MW hydroelectric project with accessory uses along the Hanalei River on TMK's: 5-4-1: 1; 5-4-2: 2; and 5-3-1: 3 at Hanalei, Kauai, Hawaii.

Maps of the general location of the area under consideration are on file for inspection at the Department of Land and Natural Resources, 1151 Punchbowl Street, Room 131, Honolulu, and at the Department of Land and Natural Resources' Offices in the State Office Buildings at Hilo, Hawaii; Lihue, Kauai; and Wailuku, Maui.

BOARD OF LAND AND NATURAL RESOURCES

SUSUMU ONO, Chairperson and Member
Dated: October 8, 1986

PUBLICATION DATE: October 1[illegible], 1986

HONOLULU STAR-BULLETIN
GARDEN ISLAND

Island Power Company, Inc.

January 26, 1987

Mr. Kent H. Keith
State of Hawaii - DPED
P.O. Box 2359
Honolulu, Hawaii 96804

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Keith

This acknowledges receipt of a copy of your letter of testimony dated November 6, 1986.

We appreciate your continued support of the project and your comments with respect to the environmental and social acceptability of developments such as this.

No change or additional information will be added to the DEIS as a result of your comments.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

PUBLIC HEARING

CONSERVATION DISTRICT USE APPLICATION
FOR
HANALEI RIVER HYDROELECTRIC PROJECT

by

Kent M. Keith
Director
Department of Planning and Economic Development

November 6, 1986

Hydroelectric power is not new to the people of Kauai where, during a normal rainfall year, present facilities provide 16 percent of the Island's electricity in an environmentally and socially acceptable manner. The Hanalei River hydroelectric power plant can contribute an additional 29 million kilowatt hours of electricity annually in an equally acceptable manner.

Waialeale not only provides the source of Kauai's hydropower, but also provides the rainfall that produces biomass in the form of sugarcane and tree crops. If Kauai's hydroelectric and biomass potential were fully developed, the Garden Island could become totally energy self-sufficient for electrical generation.

The State Department of Planning and Economic Development supports the Hanalei River hydroelectric project and other desirable alternate energy technologies, such as biomass, that can further reduce Hawaii's dependency on imported petroleum and provide for greater economic stability throughout the State.

January 26, 1987

Island
Power
Company,
Inc.

Ms. Carol M. Wilcox
111 Royal Circle
Honolulu, Hawaii 96816

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Ms. Wilcox:

This acknowledges receipt of your letters to Mr. Susumo Ono and others, summarizing your comments concerning the above referenced project.

You have expressed that your major area of concern with the proposed project is confined to the possible impacts to the Hanalei River Estuary and Hanalei Bay. You have also made mention that certain information be included in the DEIS including the effects to commercial and recreational fishing, the effects of increased siltation to the taro fields, impacts from the access road, change in land use due to the access road, effects to ground water of damming up nearly one-half of the Hanalei River and diverting several tributaries, impacts caused by the size of the reservoir impoundment, correct placement and height of powerline to avoid impacts to bird flight patterns and that Hawaii's free flowing rivers be protected. You have also expressed that a baseline study of the Hanalei Estuary and others are needed prior to any changes of use in the Hanalei River Basin.

The DEIS will include an assessment of the probable impacts caused by the proposed project, including the areas of concern you have mentioned. The proposed project would be constructed utilizing sedimentation and erosion control methods in order to minimize the impacts to downstream uses caused by construction related impacts.

The originaly proposed permanent access road along the penstock route has been ommited from the development plans. This will significantly change the scope of the project and related impacts to the Hanalei River and downstream uses. Any changes to siltation and sedimentation will be short-term and confined to construction related activities.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

The powerhouse is located nearly one river mile upstream from the China Ditch Diversion and one and one-half miles upstream from the Kuna Ditch Diversion. All of the flows diverted for power production will be returned to the natural channel from the powerhouse. The project will not cause changes or impacts to the amount of flow in the Hanalei River below the powerhouse. Further, the impoundment behind the main diversion weir will cover less than one acre of land and will contain less than one acre foot of water. Thus, the project will not store or regulate flows in the Hanalei River.

A continuous minimum flow will by-pass the main diversion weir preserve the existing wildlife and aquatic resources in the project area. The project will not divert 44% of the stream flow which will also remain in the river channel. This will minimize the impacts to the existing wildlife and aquatic resources in the Hanalei River. The surface waters in the Hanalei River are primarily a residual of rainfall in the basin which are in excess of the groundwater needs. The proposed project will not effect the groundwater table in the Hanalei Valley. The Wainiha project is a working example that groundwater levels are not impacted by a project such as this.

Island Power Company believes that the impacts of the proposed project can be adequately minimized or mitigated and will not cause significant impacts to the surrounding area. The principal impact will be the aesthic appearance of a lesser flow in the river channel along the diverted reach. This will not effect any of the uses of the river or flows downstream of the project.

Island Power recognizes the importance of information such as the baseline study of the Hanalei Estuary which you are working to accomplish. Island Power will cooperate in any way possible to assist you in this endeavor. However, the EIS will quantify and identify all of the potential impacts to the Hanalei Estuary and Hanalei Bay and will demonstrate that these impacts will be short-term and insignificant. If the baseline study cannot be completed in a timely manner, the proposed project should not be delayed if proper demonstration of insignificant impacts can be made.

Ms. Carol M. Wilcox
January 26, 1987
Page 3

We believe this project is beneficial to Kauai and can be constructed and operated without causing significant impacts to the Hanalei Valley. We commend you for your efforts and genuine concern for the environment and residents of Hawaii. We will support you as much as possible in your endeavors.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt
President

aa

Carol M. Wilcox

111 Royal Circle, Honolulu, Hawaii 96816

RECEIVED
86 NOV 11 A 58
DEPT. OF LAND
& NATURAL RESOURCES
STATE OF HAWAII

November 11, 1986

Mr. Susumu Ono and BLNR
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

RE: CDUA # KA-9/11/86-1927
Hanalei Hydroelectric Project

Dear Mr. Ono and members of the Board,

Thanks for your attention at the public hearing of 11/6/86. I understand that the BLNR has now met all legal requirements for public hearings on this matter, and that any further hearings is a matter of Board discretion.

In view of the scale of this project and its potential impacts, I wish to respectfully request the Board consider holding a public hearing in Hanalei once the EIS is completed, so that the public can participate in the review process. Could your Board make such a commitment at this time? Looking forward to hearing from you.

Sincerely,

Carol Wilcox

Carol Wilcox

enc: copy of letter to Peter Apo

'86 NOV 17 PM 1:53
OCEA
RECEIVED

November 11, 1986

Mr. Richard Kawakami, Representative
State House of Representatives
State Capital
Honolulu, Hawaii 96813

RE: CDUA #KA-9/11/86-1927
Hanalei Hydooelectric Rroject

Dear Mr. Kawakami,

Both through my work on the Ad Hoc Committee and personal inquiries, I am increasingly disturbed by the potential adverse impact of this Hanalei Hydroelectric Project on the taro industry, fishing industry, and recreational and scenic resources. I am enclosing a copy of my testimony at the BLNR meeting of 11/6/86 for your information. I am asking the OEQC for Consulted Party status.

I understand the bond issue for the Hanalei Hydro was sponsored by you. I have some questions regarding this matter.

1. Does this mean you endorse this project?

2. Does this indicate legislative endorsement of this project?

3. Was there a public hearing specifically regarding the Hanalei Hydro? If so, when, and where was it held and what was the notification?

4. An EIS has been required by the OEQC. Since this is a bonded project, does that mean that the State may end up paying for the EIS?

5. Do you know if there are any local investors in Island Power Co. Inc. or Hanalei Power Co.?

What concerns me is the perception at the State Agency and at the County levels that legislative approval of the bond constitutes outright or tacit approval of the project itself. This prior to EIS or public review. This is, I understand, highly unusual.

Would you please clarify these matters for me. Looking forward to hearing from you.

Sincerely,

Carol Wilcox

Carol Wilcox
enc: my two letters of testimony
cc: Susumu Ono, DLNR
Avery Youn, Kauai Planning

November 11, 1986

Mr. Peter Apo, Representative
House of Representatives
State Capital
Honolulu, Hawaii 96813

RE: CDUA # KA-9/11/86-1927
Hanalei Hydroelectric Project

Dear Mr. Apo,

The need for an inventory and baseline study of our Hawaiian estuaries and river systems is increasingly evident. Although an inventory has not been completed, I am confident it will identify our North Shore streams and rivers as among the few remaining in a natural condition.

The Lumahai River may be the State's most pristine. The Hanalei River is among the top 10. Their estuaries are recognized as extremely important.

The Ad Hoc Committee has recommended a baseline study of the Hanalei River estuary using the Lumahai and Wailua Rivers for comparison. If we added the Wainiha River to this study, we would have a really remarkable selection of waterways. They would all four come off the same water source - Waialeale. They would range from most pristine (Lumahai), to one impacted by a hydroelectric plant (Wainiha), to one impacted by some water diversion and boat traffic (Hanalei), to one impacted by hydroelectric, boat use, dredging, and diversion (Wailua). There is no place else in this State that can offer such an opportunity.

Do you agree that there is some urgency in this matter? Could you propose legislation to initiate a baseline study at the next session? Could we apply state tax windfall money to this study? Looking forward to your response.

Sincerely,

Carol Wilcox

cc: Susumu Ono
cc: Avery Youn
cc: Roger Evans
Enc: my two letters of testimony

RECEIVED

'86 NOV 17 AM 8:05

DLNR
OCEA

November 11, 1986

1

Director OEQC
567 Halekauwila Street
Honolulu, Hawaii 96813

RE: CDUA # KA-9/11/86-1927
Hanalei Hydroelectric Project

Dear Director,

I understand an EIS has been required by your department for the above application. I would like to request "Consulted Party"Status". I have expressed my concerns at the DLNR hearing of 11/6/86. If I need to provide you with further information about myself in order to be qualified as a "consulted party", I would be happy to do so.

Please diredt any correspondance to the above address.

Sincerely,

Carol Wilcox

Carol Wilcox

cc: Roger Evans

enc: my two letters of testimony

November 11, 1986

Mr. Avery Youn, Director
Kauai County Planning Department
4280 Rice Street
Lihue, Kauai 96766

1

RE: CDUA # KA-9/11/86-1927
Hanalei Hydroelectric Project

CERTIFIED MAIL

Dear Avery,

Regarding the proposed Hanalei Hydroelectric Project, I have some questions about the process.

1. Does any part of this project (including powerlines) fall within the SMA?

2. If so, in view of the fact that it is a $15 million dollar project (as stated at public hearings and in the EA), will the county be requiring an EIS and public hearing?

3. Regardless of SMA status, this project is specifically opposed in the Kauai General Plan. Will the county so indicate to the DLNR?

4. I wish to be part of the review process in this case. I am asking the OEQC for "ConsultingParty Status". I would appreciate your department copying me in on documents and correspondance pertinent to this matter. Does this meet with your approval? Are there any forms I need to fill out?

Looking forward to hearing from you.

Sincerely,

Carol Wilcox

cc: Roger Evans

enc: copy of my two letters of testimony
copy of letter to Kawakami
copy of letter to Apo

RECEIVED

'86 NOV 17 AM 8:05

DLNR
OCEA

AdHoc Committee for North Shore Recreationsl
Water Use Management Plan
Department of Transportation-Harbors Division
79 S. Nimitz
Honolulu, HI 96813

November 6, 1986

Mr. Susumo Ono
Board of Land and Natural Resources
P.O.Box 621
Honolulu, HI 96809

7

Dear Mr. Ono,

Thank you for inviting this AdHoc Committee to testify on the matter of the Hanalei Hydroelectric Project. The AdHoc's area of concern is confined to the possible impact this project may have on the Hanalei River Estuary and ~~the~~ Hanalei Bay. Since we have reason to believe that the project may adversely impact these areas, we ask that this committee be designated an Interested Party. As we understand it, we would then be copied in on the field officer's findings and given an opportunity to rebut. We also request a copy of the EIS when it is complete. We respectfully ask that the Board conduct a public hearing persuant to the completion of the EIS, so that the public may have a chance to comment with the benefit of that study.

The AdHoc Committee wishes to go on record as being opposed to this project until the results of certain studies and the compilation of certain information is completed. We do this as a result of reading the Environmental Assessment prepared by the applicant, as well as exploring the problems that are occuring nationally in hydro-electric development.

Some of our objections are as follows;

1. The AdHoc Committee upholds the stated intent of the North Shore Plan which designates the North Shore as a major scenic and recreational resource. It is thus with considerable concern that we view the statement in the EA that states "The quality of community life will be affected, but the nature of the quality is believed to be related to recreational activities and aesthetic perception more than any other factors." In this area the "recreational activities and aesthetic perceptions" are of extremely high value.

2. The AdHoc Committee has recognized the need for a base line study of the Hanalei River Estuary, (as well as the other North Shore EsTuaries,) before any commercial or extensive changes be allowed on these rivers. Although this recommendation was made specifically in reference to commercial boat operations, it equally applies to a hydroelectric plant on this river, which experience shows will cause siltation of the river mouth and decreased frequency of low flows.

3. The Hanalei River Estuary is identified in a DLNR survey as being an extremely important fishing nursery. The impact of siltation and decreased stream aeration may substantially alter this characteristic, and consequently have an negative impact on the commercial and recreational fishing industries. Experience on the mainland points to this very real possibility. We specifically ask that the EIS include studies by limnologist and aquatic biologist experts.

4. Increased siltation of the Hanalei River Mouth would be ~~extremely~~ undesirable from the recreational and aesthetic point of view.

The AdHoc Committee feels that existing evidience points to a negative impact on the ~~extremely~~ valuable aesthetic, recreational and economic resources of the Hanalei River and that this use should be considered ~~extremely~~ carefully and with the utmost public and expert review before any determination be made. We ask that the EIS include the following information:

Effects of increased siltation and low stream flow on a) vegetation on river banks b) aeration of water and possible subsequent impact on river plants and plankton. 3) Commercial and recreational ocean-going fish using estuary as nursery.

We also would appreciate a response regarding whether the Board will be holding another public hearing once the EIS is completed, or if this will be the last opportunity for public imput.

Once again, we thank you for inviting our testimony.

Sincerely

Carol Wilcox

Carol M. WIlcox
Spokesman, AdHOc Comm

111 Royal Circle
Honolulu, HI 96816

2

Carol Wilcox
111 Royal Circle
Honolulu Hi 96816

November 6, 1986

Mr. Susumo Ono
Board of Land and Natural Resources
Box 621
Honolulu, HI 96809

Dear Mr. Ono and Members of the Board,

As an adjacent land owner I respectfully request that I be considered an "Interested Party" in the matter of the Hanalei Hydroelectric project File No. KA-9/11/86-1927. I understand this to mean that I will receive copies of important relevant documents pertaining to this project, in particular the field officer's findings, and will be given an opportunity to comment on those findings. I would also like to request a copy of the final EIS, and would like to know if the Board is planning to hold a hearing once that information is available.

Having read the Environmental Assessment, I would like to suggest that the following information ~~is important be~~ included in the EIS.

1. The effect of siltation and reduced stream flow on the taro farmers has not been addressed. There is sufficient reason to be concerned that the impact will be extremely negative.

2. The road indicated on the EA map extands only to the Powerhouse. However, in the description of the project there is a road to the diversion weir. Runoff and siltation from this road into the stream bed has not been addressed.

3. The major land use change into the mauka portion of the valley which would occur with an access road has not been addressed.

4. The effect of damming nearly one half of the Hanalei River and diverting seven tributeries on the ground water supply of the Hanalei watershed has not been addressed.

5. The size of the reservoir and consequent impact has not been addressed.

6. The placement and height of the power line has not been addressed. Incorrect placement may well interfere with bird flight patterns and nesting areas, and should be specifically designed to avoid such impact.

7. It is with great concern that I read the Environmental Assessments conclusion that "There are no threatened or endangered species affected." This is in direct contradiction to the Timbol-Heacock preliminary study, to the reason for the adjacent Wildlife Refuge, to common sense. It calls into question the sincerity of this applicant in the EIS process.

As a member of and spokesman for the AdHoc Committee for a North Shore Recreational Water Management Plan, I personally concur with that committee's call for certain studies, and especially a baseline study, to be conducted before any changes ~~xxx~~ be allowed on this river. I wish to go a step further.

Several years ago I conducted a survey of Plantation Irrigation Systems in the State of Hawaii for the DLNR, Historic Sites Department. It was through doing this survey that it was impressed on me, as I'm sure you Board members are well aware, that there are almost no free-flowing rivers or streams left in Hawaii. For example, I have been told that 70% of Oahu's rivers no longer flow to the ocean. By the early 1900's nearly every single river and stream in Hawaii had been dammed, for hydroelectric power and for irrigation. By the same token, nearly every estuary was altered for one purpose or another.

It is thus that the north shore of Kauai has some of the few remaining pristine or nearly pristine rivers and intact estuaries in Hawaii. We cannot know the importance of these systems until we evaluate them.

The importance of free flowing rivers and natural estuaries is being increasingly appreciated on the mainland. It is for this reason that the federal Scenic and Wild Rivers Act was passed, requiring all states to compile an inventory of their rivers and identify those most worth of protection. It is also for this reason that HR44 is pending in congress, an act to give our few remaining free flowing rivers some environmental protection.

We already know that the Hanalei River is a very important resource, we just don't know HOW important. We know that the hydroelectric will have negative impacts on many aspects of this river. It may be wise to move very slowly before allowing this sort of project. Maybe we should take this opportunity to study this and other North Shore rivers to our satisfaction. If the hydroelectric plant is a good idea now, it will be a good idea years from now, when the other environmental and aesthetic questions have been answered.

Thank you for your attention,

Carol Wilcox

Carol M. Wilcox

February 2, 1987

Island Power Company, Inc.

Ms. Hermina Morita
P.O. Box 3130
Princeville, Kauai, Hawaii 96722

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Ms. Morita:

This acknowledges receipt of a copy of your letter dated November 6, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that the public did not have enough information on the project to adequately make comments in the public meeting on November 6, 1986. You further expressed that another public meeting should be held after the EIS has been completed. You are concerned that the Hanalei Project has a smaller than usual generating capacity and that existing plants should be upgraded. You also have expressed that many of the assessments of project impacts will be made on pure speculation and cannot be accurately predicted.

Island Power is in the process of completing the EIS in its "Draft" form which will be submitted to the State of Hawaii, DLNR and OEQC on February 5, 1987. This document will clearly describe the project and will adequately identify, assess and address all of the expected impacts of the project along with mitigative measures to minimize them. We will make sure that you receive a copy of this document.

The Hanalei Project as proposed would be the largest, most productive hydroelectric plant on Kauai. This project is greatly needed not only to reduce oil dependancy, but to strengthen Kauai Electric's System on the North Shore. There is a great distance between Kauai's major generating facilities and the North Shore which creates a tremendous amount of powerline losses from transporting power so far away. The Hanalei Project would help to insure that the North Shore maintain power in the event of a disaster or breakdown of the powerlines from the South Shore area.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

Island Power recongnizes your concerns that the project meet the North Shore Development Plan goals and that a new road into the Valley will increase traffic in the area. We have ommitted the permanent access road along the pipeline which will greatly reduce the expected impacts caused by the project. Permanent access will only be necessary to the powerhouse area. The powerplant will be controlled remotly by computer and will not require constant supervision. In the event of routine maintenance or plant shutdown, personell will need access to the powerplant. There will however, be an increase to the traffic on this road during the 12-14 month construction period.

There are a limited number of resources for hydroelectric development on Kauai. The Hanalei site has the greatest potential of any available sites on the Island. Existing projects could be upgraded, but they are small in size and would make little difference to Kauai's energy needs. The second Wainiha Project would be a benefit, but Mcbryde has not found it economical to construct the project at this time.

Island Power believes that the Hanalei Project would be beneficial to Kauai and can be constructed and operated without causing significant impacts to the environment. The principal impact of the project will be the aesthic appearance of a lesser flow in the river between the diversion and powerhouse. All the diverted flow will then return to the river well upstream of the existing uses and residential areas. A continuous flow will by-pass the diversion weir and will remain in the river to preserve the wildlife and aquatic resources in the diverted reaches. Further, 44% of the river flow will not be used by the project and will also remain in the natural channel.

Hydroelectric power generation is a long-standing, proven method of providing energy. It does not consume resources or emitt pollutants into the environment through a burning process. It is the cleanest, most practical way of providing a significant and dependable amount of power with few environmental consequences. If care is taken to minimize and mitigate these impacts, power can be produced in harmony with the surrounding environment.

The Wainiha Project demonstrates that these projects are beneficial and can co-exist with the environment and downstream uses.

It is our understanding that a public hearing will be held after the EIS is complete. We will look forward to your comments on the DEIS in the near future.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

HERMINA MORITA
P.O. Box 3130
Princeville, Kauai, Hawaii 96722
Phone: (808) 826-9828/826-6612

November 6, 1986

Mr. Susumu Ono, Chairman
Board of Land & Natural Resources
State of Hawaii
Department of Land & Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Conservation District Use Application for 6.0 MW Hydroelectric Project with Accessory Uses Along the Hanalei River, at Hanalei, Kauai, Hawaii
File No. KA-9/11/86-1927

Dear Mr. Chairman and Members of the Board:

I would like to be made a party to this contested case as I feel insufficient information was made available to the public prior to this hearing.

On October 11, 1986 I received a letter and hearing notice from the Department of Land and Natural Resources regarding the above mentioned project. On October 13 I called the telephone number listed in the letter, the Office of Conservation and Environmental Affairs, to request more information on the application and was advised that I should go to the Land Management Office in Lihue.

November 3, 1986 was the first opportunity I had to research the project so I could at least make an intelligent decision on the project as its location is in the vicinity where I live. The only information that was available at the Land Management Office in Lihue was a memorandum dated November 6 addressed to the Board summarizing comments from various divisions and an application from Island Power Co. requesting access to State lands to prepare an Environmental Impact Statement on the project.

On November 4, 1986 I contacted Mr. Mervyn Kimura of Island Power Co. to request a copy of the Environmental Impact Statement (EIS) and was advised that it has not been completed and would not be available for approximately six months.

In view of the lack of information available on this project, I would like to request that another public hearing be scheduled after the EIS has been completed, made available and adequate time is given to the public to review and comment on the EIS.

In the interim I hope the Board will consider the following:

In reviewing the North Shore Development Plan Update, a county ordinance it appears that this project will not meet its criteria. The plan states:

> "maintenance of the natural beauty and ecological systems that characterize the North Shore must take priority over any new development." (page 6)

> "Surface water diversions should be limited to agricultural needs in the North Shore area and should only be permitted if it can be clearly demonstrated that any adverse impacts will be adequately mitigated." (page 8)

Once this plant is built it will be difficult to correct any adverse environmental impacts. I assume many of the assessments on the project are purely speculation, no one can accurately predict what kind of impact this facility will have on the environment, so would it not be better to improve upon existing facilities than to take a pristine area with existing conservation guidelines to build in?

Are the existing hydroelectric facilities on Kauai producing to their maximum capacities? If not, will it be possible to improve upon these facilities to do so?

One understands the desire for the island to be less dependent on imported oil to generate electricity but is the hydroelectric project at Hanalei River necessary to meet this objective?

It is my understanding that the proposed plant has a smaller than usual generating capacity. How long and how much electricity does this plant have to produce to justify the inital outlay of capital? I am asking this question because according to a Garden Island article dated April 30, 1986 the state legislature approved a $12 million bond for this project and the underwriter expects a significant portion of the bonds to be purchased locally. Is this project economically prudent?

The Hanalei Homestead area is a "remote" area which my neighbors and I enjoy. Are there any studies on the sociological/cultural impact this facility may have on the area especially with an access road further into the valley than the existing roads now allow? "Improved" road conditions will increase traffic through a wildlife refuge area and areas now only accessible by hiking.

The National Trust For Historic Preservation Western Regional Conference held last year cited Hanalei Valley as one of the ten most important sites for rural presevation in the Western part of the United States. This week it was announced that a Cultural Resource Management Plan has been funded by the Gerbode Foundation and is being supported by the Mayor of Kauai, Representative Peter Apo, 1000 Friends of Kauai and many concerned Kauai residents.

Some of the project goals and objectives for the Hanalei project are:

* to increase recreational opportunities that do not damage shoreline, historical and natural resources

* to protect and enhance the visual quality of the valley

* to protect areas of special character through techniques such as establishment of one or more historic districts

* to educate both residents and visitors about the unique historic, rural, cultural, and natural resources and fragile nature of Hanalei Valley

* to increase awareness among citizenry about these critical issues and help them and government agencies develop techniques designed to protect the area and its special quality of life

In closing, this application has an impact on the ideals, goals and objectives trying to be reached and compromised by environmentalists, historians, residents, public officials and many other concerned citizens. Without proper information available it will be difficult to make intelligent decisions. If a decision has to be made based on this hearing alone with no other public input after the EIS has been completed then I will asked that this application be denied as an unique environment is at stake that can have no value placed on it. It is part of Kauai's heritage.

Thank you for the opportunity to participate.

Sincerely,

Hermina Morita

Hermina Morita

Island
Power
Company,
Inc.

January 26, 1987

Mr. Kelvin L. Kai
Citizens Utilities Company
P.O. Box 278
Eleele, Kauai, Hawaii 96705

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Kai:

This acknowledges receipt of a copy of your letter dated November 6, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

We appreciate your continued support of the project and your providing of information to be included in the DEIS.

No changes or additional information will be added to the DEIS as a result of your comments.

We will keep you apprised of our progress in this process and thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

CITIZENS UTILITIES COMPANY

P. O. BOX 278 · ELEELE, KAUAI, HAWAII 96705

RECEIVED '86 NOV 10 A10:54 DEPT. OF LAND & NATURAL RESOURCES STATE OF HAWAII

RECEIVED '86 NOV 10 PM 4:27 DLNR OCEA

November 6, 1986

Honorable Susumo Ono, Chairman
Department of Land and
Natural Resources
State of Hawaii
P. O. Box 621
Honolulu, HI 96809

HAND DELIVERY

Dear Mr. Ono:

We are the public utility providing electric power service to customers on the Island of Kauai.

By the end of 1986, our net generation requirement to serve our customers is estimated to be 268 million kwh. This requirement would represent an 8.0% increase in customer requirements over the year 1985.

In producing the 268 million kwh in 1986, we anticipate that approximately 40% will be purchased from plantation sources, i.e., largely produced from the burning of bagasse and hydroelectric sources. The balance of the energy will be produced by Kauai Electric by burning oil. In producing this energy, Kauai Electric will burn some 350,000 barrels of oil.

Our company's policy and practice is to reduce our dependence on oil fired generation by seeking to purchase all available energy from alternate energy producers and to encourage new resources. Since geothermal and undersea cables do not appear to be a viable alternate for Kauai, the mature technology of hydroelectric power and its development is a very real possibility at a number of sites on the Island of Kauai including the Hanalei project. The Hanalei project's energy output if developed would represent approximately 8% of our total system output. This output would displace over 45,000 barrels of oil per year.

We believe another benefit of the project is what we call "meeting diversity of load." Although this project is not a firm energy source, we do realize that for certain periods of the year, energy from the project would supply areas of Princeville, Hanalei and other areas on the north shore. This allows KE to use less oil-fired generation at its Port Allen facility and in turn displaces additional line losses and provides local area protection. In this regard, the Hanalei project will improve the reliability to the north shore which is now served by a single, radial 57KV transmission line.

We urge that this necessary and desirable project be permitted to proceed in a timely manner for the benefit of the Island.

Very truly yours,

Kelvin L. Kai, Manager
Transmission & Distribution

KLK:ey (558C)

Island
Power
Company,
Inc.

January 26, 1987

Mr. William F. Mowry
Box 929
Hanalei, Hawaii 96714

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Mowry:

This acknowledges receipt of a copy of your letter dated November 6, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that the Hanalei Project is not needed and that double the amount of power could be produced at the second Wainiha plant, which you understand was blocked by the government. You also are concerned that the power rates will not be reduced by the project but taxpayers will be forced to fund it by bonding dollars and that the hydrostatic pressure will be reduced by the project which will bring about salt water infusion. You also express concern over a potential silt problem and that a more comprehensive EIS should be prepared for this project.

An Environmental Impact Statement is currently being prepared in its "draft" form which will be submitted to the DLNR and OEQC on February 5, 1987, which will address all of the impacts of the proposed project to the Hanalei Basin and project area. The proposed project will produce 29.5 million kilowatt hours of electricity each year with a maximum capacity of 8,000 kilowatts. This would be the largest and most productive hydroelectric project on the Island of Kauai, including either of the Wainiha projects. Further, the second power plant on the upper Wainiha was approved by the government in 1983, but as we understand, has been put on hold by Mcbryde Sugar.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

The Hanalei River Hydroelectric Project will not immediately reduce power rates but will offer substantially lower rates for power to Kauai Electric in the future.

The use of a special purpose revenue bonds to fund the project will not effect the taxpayers of Hawaii. The bonds will be sold to the public on the open market which will allow the buyers to write off their interest income from federal taxes. Any participation by Hawaii residents will be of their own choice.

A continuous flow will by-pass the project diversion and will remain in the river channel. Further, 44% of the river flow will not be diverted for power production. All of the diverted flows will be returned to the river channel over six (6) miles upstream from the mouth. These factors will insure that the hydrostatic pressure will not be impacted by the project.

The existing project in the Wainiha Valley demonstrates that a development of this nature will not cause the catastrophic events which you have concern for.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

William F. Mowry
Box 929
Hanalei, Hi. 96714

November 6, 1986

Committee Chairman:

I am unable to attend your hearing, but would like my statement of opposition to be put into the record.

We are told that we need the additional hydro-electric power that would be generated by putting a hydro-electric plant at the head waters of the Hanalei River. This is without merit. Additional capacity (possibly double the amount of power) is easily possible and much more economically feasible at Wainiha than at either a Hanalei hydro project or a Lumaha'i hydro project. I understand the enlargement of the Wainiha Plant was blocked by the government years ago.

We have also been told that the taxpayers will not have their power bills reduced one cent, and yet the taxpayer is being told that the project will be funded by bonding dollars at taxpayer expense.

This proposed project may also lower the under ground hydrostatic water pressure which presently holds back salt water from underground infusion. If the hydro static pressure is changed it could bring about salt water infusion into my buffalo pasture and I may wind up with a salt marsh. According to the North Shore Ordinance, agriculture is to be preserved at all costs, certainly over industrial projects. It states that there will be no diversion of agricultural waters permitted except for agricultural use.

I am also worried about what the silt problem is going to do. All it would take is just a thin film of silt washed out to the reef, and the reef would die. There needs to be a more comprehensive E.I.S. done.

I strongly recommend that this project be denied approval. If that is not possible, I urge this Committee withhold any approval until The Hanalei Project Advisory Committee, funded by the Wallace Alexander Gerbode Foundation, has had a chance to study the proposed project and come up with a recommendation.

Mahalo,

William F. Mowry

William F. Mowry

November 6, 1986

Mr. Susumu Ono, Chairman
Board of Land & Natural Resources
State of Hawaii
Department of Land & Natural Resources
P. O. Box 621
Honolulu, Hawaii 96809

Subject: Conservation District Use Application for 6.0 MW Hydroelectric Project with Accessory Uses Along the Hanalei River, at Hanalei, Kauai, Hawaii
File No. KA-9/11/86-1927

Dear Mr. Chairman and Members of the Board:

This letter will express my concern for the proposed hydro electric plant to be constructed in Hanalei Valley. There seems to be very little information available on the impact the plant will have on the "China Ditch", the Hanalei river, the surrounding residents, the o'opu fish and the taro fields.

As a taro farmer, the effects of any water diversion during construction and operation of the plant need to be addressed. The construction period may also produce rubbish and silt that will enter our existing ditches and underground pipelines.

Until a thorough explanation of the plan is published for all residents to fully understand this plant, I propose that any decision to proceed should be tabled until another public hearing is held in fairness to those that would like to express their opinions.

I further propose that any public information hearing be held in Hanalei to allow the community to respond. I am not able to attend this meeting in person since I have an infant to care for. However, if this meeting was held in Hanalei, it would allow more residents to attend.

I further propose that any decision to proceed be tabled until the Hanalei Project, in which I am participating in, is completed.

The Hanalei Valley retains its scenic beauty as it has for a 100 years. Let us be very careful of this fragile environment. Let us not make a mistake which we will regret and ruin what nature has created over the centuries.

Thank you for allowing me this opportunity to voice my concern. Please send me any information regarding this plant and keep me on a mailing list.

Sincerely,
Rane Haraguchi
P.O. Box 427

Island Power Company, Inc.

January 26, 1987

Ms. Karal Haraguchi
P.O. Box 427
Hanalei, Hawaii 96714

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Ms. Haraguchi:

This acknowledges receipt of a copy of your letter dated November 6, 1986 to Mr. Susumo Ono, summarizing your comments concerning the above referenced project.

You have expressed concern that adequate information be available to local residents identifying potential impact of the project to the China Ditch and other irrigation systems, the Hanalei River, the O'opu Fish and the Taro Fields.

The DEIS will address and identify how the project will impact each of the areas you have mentioned in your letter.

The project will introduce a minor amount of sediment into the upper Hanalei River during construction activities, but erosion control methods will be utilized to minimize these impacts. Operation of the project will not introduce sediments into the river. A continuous by-pass flow will remain in the river channel at all times to preserve the existing wildlife and aquatic resources including the O'opu Fish. Further, 44% of the total river flow will not be used for power production which will also remain in the river channel.

The project will not store or regulate water flow and the powerhouse will discharge all of the diverted flows back into the river channel nearly one mile upstream from the China Ditch Diversion. The project will not affect the water temperature or chemical composition. Thus, the project will not have significant impacts to the existing downstream uses on the Hanalei River.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo, Kauai
Hawaii. 96741

We will submit the DEIS to the State of Hawaii, DLNR and OEQC on February 5, 1987. Copies of the DEIS will be made available for public review from these agencies. If you have any difficulty gaining access to this document, we will see that you receive one.

We appreciate the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

January 16, 1987

Island Power Company, Inc.

Mr. Ernest Kosaka
U.S. Fish & Wildlife Service
300 Ala Moana Blvd.
Honolulu, Hawaii 96850

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. KA-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Kosaka:

This acknowledges receipt of a copy of your letter dated November 5, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

You have expressed concern that the DEIS should include; a detailed biological survey, botanical and ornithological surveys, discussion of results of IFIM study, summary of use and cummulative impacts to endangered Hawaiian water birds, discussion of project related impacts to the wildlife refuge, discussion of effects caused to water quality from access roads, discharge measurements to verify accreation flows, discussion of cummulative impacts of this project and similar projects on native aquatic fauna and a discussion of temperature changes and dissolved oxygen distribution. You also mention that a 36 cfs conservation flow has been recommended by Mr. Timbol and Mr. Heacock based upon their preliminary studies. This recommendation was based upon historic flow measurements recorded at U.S.G.S. Station 16103000.

All of the studies and informational concerns you have expressed will be addressed and/or included within the DEIS. However, Island Power Company does not believe that an IFIM study should be included within the DEIS for several reasons.

Firstly, there are no individuals or companies in the private sectors of the Islands who can or will perform such a study. The only individuals capable of performing such a study are within the public sector and are occupied with other matters.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

Secondly, the IFIM study is a new concept to the Islands and baseline data is very limited. The study could be too inconclusive for use in the EIS and could cause confusion and controversy. Island Power believes that until more baseline data is gathered and the IFIM is tested and proven to be an effective method for accurately determining conservation flows for aquatic habitat on the Islands, it should not be included in the EIS.

A possible solution would be to include the IFIM study as a condition within the CUDA permit prior to construction activities, to determine the adequacy of any minimum by-pass flows recommended in the CDUA permit. The study would be funded by Island Power Company and would be performed in conjunction with the U.S. Fish & Wildlife Service and U.S. Army Corps of Engineers.

Island Power Company believes that there is more than adequate information available to make a reasonable determination of a conservation flow to be used in the CDUA process.

Verification of the significant amount of accreation flows between the point of diversion and powerhouse can be determined by the use of comparison between U.S.G.S. stations 16101000, elevation 625, and 16103000, elevation 35.8, with common years of 1914-1919. A table illustrating this comparison will be included in section B-6b, "Hydraulic Investigations", of the DEIS.

The use of USGS gage #16101000, elevation 625 would be the most logical way of determining the typical low flows which occur near the proposed main diversion weir. According to historical records for the period 1925-1954, flows of 10-15 cfs have occured for extended periods of time nearly every year which has been recorded. This would indicate that the aquatic species and wildlife in the area have the ability to survive with flows of this magnitude. Further, 44% of the Hanalei River will not be diverted for power generation which will substantially add to the conservation flows released at the main diversion. This topic will be thoroughly discussed in the DEIS.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

'86 NOV 7 A 8:47

LAND AND NATURAL RESOURCES STATE OF HAWAII

ES
Room 6307

NOV 5 1986

'86 NOV 10 PM 4:29 OCEA RECEIVED

Mr. Susumu Ono
Chairperson, Board of Land and
Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, HI 96809

Re: Conservation District Use Application KA-1927, Hanalei Hydroelectric Project, Hanalei, Kauai

Dear Mr. Ono:

We have reviewed the referenced Conservation District Use Application and Environmental Assessment and offer the following comments for your consideration.

We have met with Mr. Clark Mower, Bingham Engineering, on several occasions to discuss this project. Based on discussions with Mr. Mower, we understand the studies identified in the following paragraphs are being conducted.

a. A detailed biological survey of the affected portions of Hanalei River and its tributaries is being conducted by Dr. Amadeo Timbol and Mr. Don Heacock. Botanical and ornithological surveys of the affected portions of Hanalei River are also being conducted by the applicant. The results of these surveys will be included in the Draft Environmental Impact Statement (EIS).

b. Currently, the applicant is proposing 10 cubic feet per second (cfs) as a conservation flow in Hanalei River. No conservation flows in the affected tributaries are being proposed. Amadeo S. Timbol and Donald E. Heacock have recommended that the conservation flow over the diversion weir be 36 cfs based on their preliminary study of Hanalei River fishes. The applicant has agreed to conduct an Instream Flow Incremental Methodology (IFIM) study of the affected portions of Hanalei River and its tributaries. Our office, in coordination with the U.S. Army Corps of Engineers, will be involved in this study. These studies will be used to determine the potential impacts to aquatic habitat, and to determine conservation flows in Hanalei River and its tributaries.

The referenced Environmental Assessment is, in our opinion, insufficient. It does not fully discuss the potential impacts of the proposed project. In particular, we recommend that the Draft EIS include a discussion of the following issues.

a. The Draft EIS should discuss the results of the IFIM study, and identify appropriate instream conservation flows for Hanalei River and its tributaries to protect native aquatic fauna.

b. The Hanalei River has been designated as essential habitat for the koloa (<u>Anas wyvilliana</u>), a listed endangered species (Hawaiian Waterbirds Recovery Plan, 1985). The EIS should describe the use of the Hanalei River by the endangered koloa and the direct, secondary, and cumulative effects of the project upon the koloa and its habitats.

c. The Draft EIS should discuss direct and secondary project-related impacts upon the Hanalei National Wildlife Refuge.

d. The EIS should discuss the effect of constructing all access roads within the project area on the water quality of the Hanalei River and on wetland habitats within Hanalei Valley.

e. Bingham Engineering is calculating the accretion of stream flow that occurs between the proposed diversion on the Hanalei River and the powerhouse site. We recommend that empirical stream discharge measurements be conducted to corroborate the accretion flow estimates. These data should be presented in the Draft EIS.

f. The Draft EIS should evaluate the cumulative impact of this project and similar hydroelectric projects on native aquatic fauna, and the recreational fishery for o'opu nakea (<u>Awaous stamineus</u>).

g. Water quality, particularly temperature and dissolved oxygen, may be altered in the affected reach of the Hanalei River. Consideration should be given to determining temperature and dissolved oxygen distribution in the stream under various conservation flows.

Our final recommendations for mitigation and conservation flows will be based on the results of the IFIM and related studies.

We appreciate this opportunity to comment.

Sincerely,

for Ernest Kosaka
Project Leader
Office of Environmental Services

cc: CE, Operations Branch
DAR
RWR, Wetlands Manager
RWR, Kilauea Point
EPA, San Francisco
Clark Mower, Bingham Engineering

January 16, 1987

Island
Power
Company,
Inc.

Ms. Letitia N. Uyehara-Director
State of Hawaii, OEQC
465 South King Street, Room 104
Honolulu, Hawaii 96813

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. KA-1927 for the Hanalei River Hydroelectric Project.

Dear Ms. Uyehara:

This acknowledges receipt of a copy of your letter dated November 5, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

You have expressed concern that the proposed project will deprive wildlife of their accustomed water source and affect stream fauna also. You further commented that the effect of this impact should be weighed against the need for independance from foreign oil.

Section E of the DEIS will address the impacts of the project to wildlife and stream fauna in the area. The project will incorporate a continuous minimum stream flow to by-pass the diversion weir and remain in the natural river channel. Further, 44% of the river flows will not be used for power production. The species of wildlife and stream fauna in the Hanalei basin only utilize or consume a minute amount of water for their survival needs. The flows which will not be diverted by the project will be substantially more than adequate for their needs. The most significant effect of the reduced stream flows in the Upper Hanalei River will be asthetic in nature.

The State of Hawaii is in a very vulnerable position with respect to its dependency on foreign oil for power production. It is not a question of "if" the oil sources become too costly or scarce, but more a question of "when" this will occur. If Kauai does not have adequate generating capability from renewable resources of its own the effect to the island would be devestating not only to the local residents, but to tourism as well.

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

The Hanalei Project is currently Kauai's best site for a hydroelectric project. Firstly, the size and amount of power which would be produced from the project would make it the largest most productive hydroelectric project on the Island.

Secondly, the location of the project is near the end of Kauai Electrics distribution grid which incurs a tremendous amount of line losses from carrying power for such a long distance from the main generating stations to the North Shore area.

The project will greatly strengthen Kauai Electrics System in the North Shore area which is a great distance from the main generating stations.

Island Power Company believes that if adequate measures are taken to minimize impacts to the environment during construction and operation of the project, Kauai's goal to reduce its energy self-sufficiency can be met without great consequence to the environment.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
465 SOUTH KING STREET, ROOM 104
HONOLULU, HAWAII 96813

LETITIA N. UYEHARA
DIRECTOR
TELEPHONE NO.
548-6915

November 5, 1986

Mr. Susumu Ono, Chairman
Board of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Ono:

Subject: Conservation District Use Application for 6.0 MW Hydroelectric Project with Accessory Uses, Hanalei River, Hanalei, Kauai (CDUA #1927)

Our primary concern regarding this project is that the five miles of penstock will deprive wildlife of their accustomed water source and affect stream fauna also. The effect of this impact should be weighed against the need to move Hawaii away from its dependence on foreign oil.

Thank you for providing us the opportunity to review this application.

Sincerely,

Letitia N. Uyehara

Letitia N. Uyehara
Director

Island Power Company, Inc.

January 21, 1987

Ms. Barbara M. Robeson
P.O. Box 369
Hanalei, Hawaii 96714

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. Ka-1927 for the Hanalei River Hydroelectric Project.

Dear Ms. Robeson:

This acknowledges receipt of a copy of your letter dated November 2, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

Since you have no comments to this proposal at this time, no changes or additional information will be added to the DEIS to address any specific topics or issues in your behalf.

We will submit the DEIS to the State of Hawaii, DLNR and OEQC on February 5, 1987. Copies of the DEIS will be made available to the public from these agencies. If you have any difficulty gaining access to this document, we will see that you receive one.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625.
Kalaheo. Kauai
Hawaii. 96741

PO Box 369
Hanalei, HI 96714
November 2, 1986

Mr. Susumo Ono and Board Members
Board of Land and Natural Resources
1151 Punchbowl Street
Room 131
Honolulu, HI 96714

Dear Mr. Ono and Board Members,

Thank you for the opportunity to make comments regarding the proposed Conservation District Use Application No. KA-9/11-86-1927 filed by Island Power Company for a hydroelectric project on the Hanalei River.

I attended the informational meeting held in Hanalei last February 1986, and at that time requested that my name be added to the list of persons who wished to comment on their Environmental Impact Statement. After checking last week with the Island Power representative, Mr. Kimura, I was told that the EIS will not be out until about 180 days from October 15. I would like to make comments about the proposal, but feel I cannot do so until I have time to read the EIS. I therefore request that another public hearing be held when the EIS is out, and the public has had a chance to study it, hold community meetings, and make comments.

Sincerely yours,

Barbara M. Robeson

Barbara M. Robeson

Island Power Company, Inc.

January 16, 1987

Mr. Raymond H. Sato
Manager and Chief Engineer
County of Kauai
Department of Water
P.O. Box 1706
Lihue, Hawaii 96766-5706

Re: Draft Environmental Impact Statement (DEIS) for CDUA permit No. KA-1927 for the Hanalei River Hydroelectric Project.

Dear Mr. Sato:

This acknowledges receipt of a copy of your letter dated October 29, 1986 to Mr. Susumo Ono, Summarizing your comments concerning the above referenced project.

Since you have no comments to this proposal at this time, no changes or additional information will be added to the DEIS to address any specific topics or issues in your behalf.

We thank you for the time and effort you have expended in reviewing and commenting on this proposal. If you have any questions or need further information, please contact me.

Sincerely,

ISLAND POWER COMPANY, INC.

Jeff Burt

Jeff Burt
President

aa

5160 Wiley Post Way
Salt Lake City,
Utah 84116

P.O. Box 625,
Kalaheo, Kauai
Hawaii, 96741

CEA

781

DEPARTMENT OF WATER

COUNTY OF KAUAI
P. O. BOX 1706
LIHUE, HAWAII 96766-5706

RECEIVED
'86 NOV 3 A8:25
STATE OF HAWAII

October 29, 1986

Honorable Susumu Ono
Board of Land
and Natural Resources
P.O. Box 621
Honolulu, HI 96809

Re: Conservation District Use Application
File No.: KA-9/11/86-1927; Development of a 6.0 MW Hydroelectric Project with Accessory Uses for Mr. Jeff Burt (Island Power Company, Inc.), Hanalei River, Kauai, TMK: 5-4-01:1; 5-4-02:2; and 5-3-01:3

We do not have a domestic water system in this area and, therefore, have no comments to this conservation district use application.

Raymond H. Sato

Raymond H. Sato
Manager and Chief Engineer

KF:at
cc: Planning Department

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

FILE NO.: KA-9/11/86-1927
180-Day Exp. Date: 3/10/87
DOCUMENT NO.: 1772B

OCT 0 3 1986

Mr. Jeff Burt, President
Island Power Company, Inc.
c/o Bingham Engineering
100 Lindsbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah 84116

Dear Mr. Burt:

NOTICE OF ACCEPTANCE AND ENVIRONMENTAL DETERMINATION
Conservation District Use Application for
a 6.0 MW Hydroelectric Project with
Accessory Uses Along the Hanalei
River, at Hanalei, Kauai, Hawaii

This acknowledges the receipt and acceptance for processing your application for a 6.0 MW hydroelectric project with accessory uses along the Hanalei River on TMK's 5-4-1: 1; 5-4-2: 2; and 5-3-1: 3 at Hanalei, Kauai, Hawaii.

According to your information, you propose to divert water from the Hanalei River by means of a concrete diversion weir approximately 10 feet high, at an elevation of 650 feet above MSL. The water will be conveyed through an above ground pressure penstock approximately 26,600 feet long, varying in diameter from 42 inches to 56 inches. Additional diversion of water will also be made from several of the larger tributaries to the Hanalei River on its westerly side.

Your proposed penstock will route the water to a powerhouse approximately 45' W x 50' L x 30' H, which will contain two pelton turbines and generators. The powerhouse will be situated on the westerly bank of the Hanalei River and will discharge the water back into the river just upstream from the China Ditch Diversion at an approximate elevation of 50 feet above MSL. A new above ground 69 KV transmission line approximately 4,200 feet long will interconnect to the existing Kauai Electric Transmission Line near the Hanalei Homesteads. The existing Kauai Electric Transmission Line will be upgraded to 69 KV, between the point of interconnection and the Princeville Substation, which is an approximate distance of 13,350 feet. The electricity will be sold to Kauai Electric, which will be distributed to their customers.

You further propose to construct a new access road approximately 12 feet wide along the penstock route which will allow access from the existing road near the Hanalei Homesteads to the diversion weir. Continuous use of the lands for operation and maintenance of the proposed project will be necessary.

Finally, you indicate that the proposed benefits from the project are derived solely from displacement of energy from Kauai Electric's system assuming fuel price escalation and power-on-line effective date of 1988. The project would contribute toward the goals of alleviation of oil dependence and increased energy self-sufficiency. The Hanalei River Hydroelectric Project, as currently proposed, will cost $15 million to construct and would produce approximately 28.7 million kilowatt hours of electricity per year or about 9% of the total energy consumed on the island of Kauai. The project would supplant the need to import 59,000 barrels of oil annually and service an equivalent of 5,400 households or 17,350 individuals, assuming the current rates of fuel oil utilization and household demands are maintained.

After reviewing the application, we find that:

1. The proposed use is a conditional use within the Protective and Resource subzones of the Conservation District according to Administrative Rules, Title 13, Chapter 2, as amended;

2. A public hearing pursuant to Section 183-41, Hawaii Revised Statutes (HRS), as amended, will be required in that the proposed use is of a commercial nature; and

3. Based on the description of the proposed actions, there may be a significant effect as defined by Title 11, Chapter 200 of the Administrative Rules, the Environmental Impact Statement (EIS) Regulations. As a consequence, we require that you submit an EIS in accordance with Title 11, Chapter 200, Administrative Rules, as established under Chapter 343, Hawaii Revised Statutes.

For your information, these Administrative Rules may be obtained at the State Office of Environmental Quality Control.

Through experience, we have learned that compliance with EIS requirements for acceptance by the appropriate authority, which in this case is the Board of Land and Natural Resources, is a lengthy, time-consuming process. Consequently, negative action on your request is required by law should you fail to complete the EIS requirements before the 180-day expiration date of your application. As a point of information, as the applicant you may ask for up to 90 day extension to this processing time frame should you deem it necessary.

As the applicant, please be advised that it will be your responsibility to comply with the provisions of Section 205-29d, Hawaii Revised Statutes, relating to Interim Coastal Zone Management (Special Management Area) requirements.

Negative action, as required by law, on your application by the Board of Land and Natural Resources can be expected should you fail to obtain from the County, thirty (30) days prior to the 180-day expiration date, as noted on the first page of this notice one of the following:

1. A determination that the proposed development is outside the Special Management Area (SMA);
2. A determination that the proposed development is exempt from the provisions of the County Ordinance and/or regulation specific to Section 205-29d, HRS; or
3. A Special Management Area (SMA) permit for the proposed development.

Pending action on your application by the Land Board in the near future, your cooperation and early response to the matters presented herein will be appreciated. Should there be any questions, feel free to contact our Office of Conservation and Environmental Affairs staff at 548-7837.

Very truly yours,

SUSUMU ONO, Chairperson
Board of Land and Natural Resources

cc: Board Member
Land Agent
County of Kauai Planning Department
County of Kauai Dept. of Public Works
County of Kauai Dept. of Water
DOH/OEQC/EC/OHA/DPED
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service

July 28, 1986

Mr. Clark M. Mower
Bingham Engineering
100 Lindbergh Plaza 2
5160 Wiley Post Way
Salt Lake City, Utah

Dear Clark:

Your letter ofJuly 25 arrived today, and the enclosures.

I am not surprised that Tom Telfer criticzed harshly the "Birds of the Lower Hanalei River System" that you included with your letter. It is not my report!

Most of the background information has been omitted for each species, most of the references have been omitted and 3 species of the birds that I discussed in my report have been omitted in this very abbreviated account.

However, our field trip occupied parts of only two days; Tom Telfer has been stationed on Kauai for many years. We would expect, therefore, that he could "tell us a thing or two" about the distribution of birds on Kauai. The seabirds that Tom mentions are predominantly nocturnal species. Moreover, according to Sincock and Swedberg (<u>Condor</u>, 71 (1969):69-71), the bulk of the Newell's Shearwaters return "in May." They may not have been coming in and calling during our one night in the mountains. Tom states (page 1 of his letter) that "there are likely populations of the endangered Dark-rumped Petrel and the extremely rare Band-rumped Petrel in the area." I would contend, however, that even if they are nesting in this area, construction and operation along the Hanalei River itself should have no serious adverse effect on the birds.

I can share Tom's concern about "dewatering" of streams and just how many of Kauai's rivers and streams are to be developed for hydroelectric uses. I discussed some of these in item 6 (page 22) of my Conclusions and Recommendations. I might point out, however, that I was hired by the R. M. Towill Corporation in Honolulu to do a job for the State of Hawaii: The Puu Lua-Kokee Hydropower Project. In 1983, the State was contemplating building a dam that would flood a substantial part of the Alakai Wilderness Preserve, perhaps the most valuable forest in the State for endangered birds and plants.

It is my ~~f~~eeling that a reasoned sense of perspective is essential in any construction project that is contemplated in Hawaii. The predominantly introduced forest and bird life in the lower reaches of the Hanalei River should be considered in a different light than endemic ohia-koa forests in the islands.

I hope that the above answers most of your questions.

Aloha,

Andy

Andrew J. Berger
1349 Kaeleepulu Drive
Kailua, HI 96734

HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
KAUAI DISTRICT
P. O. BOX 1671
LIHUE, KAUAI, HAWAII 96766

July 15, 1986

IN REPLY REFER TO
A-3-300

MEMORANDUM

TO: Mr. Libert K. Landgraf, State Administrator

FROM: Ralph E. Daehler, District Forester, Kauai

SUBJECT: Island Power Company, Inc. by Jeff Burt (ref. OCEA memo dtd 6/30/86)

Applicant: Island Power Company, Inc. by Jeff Burt

Property Owner: State of Hawaii - Halelea Forest Reserve, DLNR, Division of Forestry & Wildlife

Location: Hanalei River drainage, Halelea Forest Reserve-Portion of tax keys: 5-3-1:03; 5-4-1-1; and 5-4-2: 2, 16, 18, 21, & 47.

C.D. Subzone: (R) Resource with the exception of a small portion of (P) Protective subzone in the makai area.

Proposed Use: Develop a hydroelectric power project from the Hanalei River.

The project includes:

1. A diversion weir approximately 10 feet high, at the 650 foot elevation. (Approximately 1.75 miles "as the crow flies" downstream from the Lihue Plantation diversion weir to Wailua.)

2. Flume and penstock 26,000 feet long (above ground pipeline) varying in diameter from 42 to 56 inches.--Plus additional diversion of water from several larger tributaries along the west side of the Hanalei River.

3. Powerhouse - approximately 45' X 50' X 30 H.

4. Transmission line 69 KV approximately 4,200 ft. long.

5. Access road 12 feet wide along the entire length of the penstock.

Mr. Libert K. Lan graf
Page 2
July 15, 1986

Comments/Recommendation:

The location of the power plant, penstock line and transmission line in this proposal is positioned significantly downstream from the site described and proposed in the temporary variance TV KA-85-9.

This newly identified makai project location is not compatible with planned forest reserve public recreation projects.

For example, Hanalei Valley Trails and picnic area sites are being planned for the coming biennium budget session. One of the picnic sites is in the same area as the newly proposed power plant. Power plant and penstock would conflict with recreation values for both trail and picnic grounds.

Also-in our Forest Reserve Management planning on the newly acquired forest reserve land in the Halelea Forest Reserve, we identify the river bottom lands below the bend in the river at Puu O Miki as an excellent potential site for development of endangered waterfowl habitat and/or taro production. (This area was in taro and/or rice production in the early 1900's.) The power plant site must be located in the vicinity of the bend in the river, just mauka of Puu O Miki in order to provide the total water resource for these lands.

Mauka developments as proposed should not have significant impact on forest reserve wilderness type recreation work planned for the upper Hanalei River area as our trail and campsite development is predominately to be located on the east side of the river.

In the Environmental Assessment provided, Wildlife Biologist Tom Telfer has noted some deficiencies and concerns. His memorandum dated July 8, 1986 (attached) expresses his concern and recommendation.

Construction of a road and pipeline in the Hanalei drainage mountainside will be a real challenge that will require complete engineering -on site alignment- before construction work can begin.

I recommend consideration of the above comments in the processing of this CDUA and that pursuit of continued planning for development be conditional to re-establishing the proposed power plant in the area proposed in the application for temporary variance to conduct environmental surveys.

RALPH E. DAEHLER
District Forester, Kauai

Attach: OCEA memo dtd 6/30/86
Tom Telfer memo dtd 7/8/86

cc: Leonard Zalopany

HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
KAUAI DISTRICT
P. O. BOX 1671
LIHUE, KAUAI, HAWAII 96766

IN REPLY REFER TO

July 8, 1986

MEMORANDUM

TO: RALPH E. DAEHLER, Kauai District Forester

FROM: TOM C. TELFER, Kauai District Wildlife Biologist

SUBJECT: Comments for Inclusion with Kauai District Response to CDUA File KA 1927: Island Power Co., Inc. Hydro-electric Project at Hanalei River, Kauai

After having reviewed the subject CDUA with respect to wildlife interests, I offer the following comments:

1. The description of wildlife (pages C-9 to C-12) is not adequate in my opinion. Several important species were not even mentioned and some misleading statements were made. There is no mention of the Townsend (Newell's) Shearwater, a threatened species that nests within the Hanbalei River Basin. There are likely populations of the endangered Dark-rumped Petrel and the extremely rare Band-rumped Storm Petrel in the area. White-tailed Tropicbirds also nest within the area. Black-crowned Night Herons are residents of the Hanalei River and are not even listed. Other exotic introduced birds: The Red Cardinal, Greater Necklaced Laughing Thrush, Linnet and Ricebird were not listed.

Statements made with respect to Pueo, Hawaiian Honeycreepers galliform birds, doves, the endangered Hawaiian Bat and the mongoose are in error and/or are misleading. It appears that the material used for this CDUA was copied from similar documents with no specific relationship to the Hanalei Valley project area.

2. Page D-7, dealing with environmental impacts also seems to be very inadequate. The statement is made that "there are no endangered or threatened species affected in the project site". The endangered Hawaiian Duck (koloa) the threatened Townsend's Shearwater and possibly other species very likely would be impacted in a negative manner as a result of this project, as would other non-endangered birds. No references as to the source of the conclusions drawn were cited.

Ralph E. Daheler
July 8, 1986

This is one of several recent hydro-power projects proposed on Kauai similar in nature to those at Wainiha, Lumahai and Wailua. No thorough or meaningful study has been carried out to determine what the effects of dewatering our streams will be upon wildlife. It seems prudent to measure the effects of earlier similar hydro projects on on the environment before continuing on the same course for every major stream on Kauai.

Hanalei River has long term, yet undeveloped recreational values that need to be identified. Public hunting is a valuable resource in the area. Would penstocks hinder movement of hunters, hunting dogs and feral pigs? Will the dewatering of the Hanalei River and its tributaries impact recreational fishing potentials?

In general, the environmental impacts of this project need to be assessed much more thoroughly than they have been. I recommend denial of the proposed hydroelectric use until the impacts of similar projects on other streams on Kauai can be evaluated. A more realistic appraisal of potential adverse impacts on wildlife is needed.

Tom C. Telfer

Thomas C. Telfer

P.S. An annotated copy of the CDUA section discussed above is attached

Present at Hanalei Hydro meeting at Hanalei Courthouse, 7:00 P.M., 4-2-86.

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N. SUMMARY OF UNRESOLVED ISSUES

UNRESOLVED ISSUES

There are some potential unresolved issues with respect to the CDUA permit process thusfar.

An IFIM Study was not included in this report for several reasons. Firstly, there are no qualified individuals on the Islands who are available to perform an IFIM Study at this time. Further, adequate baseline information for the studies is just being developed and proven on the Hawaiian Islands. An IFIM Study for the Hanalei River could cause some confusion or controversy as to its result or outcome. More than adequate flow data is available to assess a minimum bypass flow for the project during this phase of the CDUA process. If the CDUA permit is approved, an IFIM Study should then be conducted for the Hanalei River. If the result of the study proves to be accurate and useful, the adequacy of the minimum bypass flow used in the study would be assessed against the data developed and proper changes or mitigation could be made.

Another potential unresolved issue is the matter of an uncompleted baseline study of several important estuaries on Kauai including the Hanalei Estuary. Although the proposed project will not significantly affect this area, completion of those studies would be useful. Several concerned individuals have expressed their views that these studies should be completed prior to authorization or construction of the Hanalei project.

The developer believes that the studies should be encourged, but processing of the permits necessary for the Hanalei project should continue concurrently with the study.

Further investigation into the Botanical and cultural resources in the project area. Prior to final design or commencement of construction more detailed studies will be made to identify these resources and recommendations can be made to avoid impacts to these resources. Preliminary studies indicate that the project will not cause significant effects to these resources.

O. LIST OF NECESSARY APPROVALS

NECESSARY APPROVALS

Approval for the CDUA permit must be given by the State of Hawaii, Department of Land and Natural Resources to construct and operate the project. Approval must also be given by the appropriate branches of the State of Hawaii for use of the land and water needed for the project.

The County of Kauai must issue a permit to construct and operate the project.

The State of Hawaii Public Utilities Commission must approve the Power Sales Agreement between Island Power Company and Citizen's Utilities Company, Kauai Electric Division.

The U.S. Army Corps of Engineers must issue a 404 Permit prior to any construction activities within the river channel.

The Federal Energy Regulatory Commission must declare no jurisdiction over the construction and operation of the project or otherwise grant a license for the project.

The project must be consistent with Federal requirements for the Coastal Zone Management Act.

The State of Hawaii must issue a water quality certification for the project.

APPENDIX

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APPENDIX I

A SURVEY OF AQUATIC MACROFAUNA IN HANALEI RIVER, AND THE POTENTIAL IMPACT OF HYDROELECTRIC DEVELOPMENT BY AMADEO S. TIMBOL PH. D., AQUATIC BIOLOGIST, DECEMBER 1986.

A SURVEY OF AQUATIC MACROFAUNA IN HANALEI RIVER, AND THE POTENTIAL IMPACT OF HYDROELECTRIC DEVELOPMENT

by

Amadeo S. Timbol Ph. D.

Aquatic Biologist

Prepared for: ISLAND POWER CO., INC.

December 1986

A SURVEY OF AQUATIC MACROFAUNA IN HANALEI RIVER, AND THE POTENTIAL IMPACT OF HYDROELECTRIC DEVELOPMENT

by

Amadeo S. Timbol Ph. D.
Aquatic Biologist

INTRODUCTION

Natural resources of oceanic islands are fragile, specially susceptible to man's influence and require special management (McEarhern and Towle 1972). Hawaii, more than 2500 miles from the nearest landmass, is such an example. According to the latest island-wide census, there are at least 336 perennial streams (Timbol and Maciolek 1978). These streams are Hawaii's principal natural freshwater environment for a variety of aquatic animals. Many of these animals are found naturally only in Hawaii and nowhere else in the world.

Cultural practicos have resulted in the dewatering of many streams for agricultural and domestic purposes. Stream flow diversion started with the early Hawaiians who built low, stone dams in streambeds to raise the level of water which could flow into ditches but there was no export from the drainage basin (Lau 1981). Streamflow diversion and export from drainage basins started with the development of large scale sugar cane cultivation. The 17-mile long Hanakua Ditch on Maui, for example, was completed in 1878 with a capacity of 60 million gallons per day (mgd) capacity. The use of streamflow to generate electricity started with the Wainiha hydroelectric facility, still the states's largest, which has been in continous operation since 1906 (The Garden Island, November 28, 1986). According to the same Garden Island report, there are seven hydropower plants now in operation on Kauai and five more are planned. Three of these five are in the Hanalei area (Lumahai River, Hanalei River and a second for Wainiha River).

Hawaiian stream macrofauna evolved under environmental conditions imposed by the streams. As a result, most of the organisms need to spend part of their life cycles in marine waters. For this reason, they must have suitable environmental conditions throughout the stream channel for their upstream and downstream migrations. Continued streamflow diversions and water development place the survival of these stream animals under stress.

Scope and Objectives

This survey is a one time limnological survey of Hanalei River. The purpose is to determine the physicochemical features and inventory freshwater macrobiota of the river to provide a general description of its ecology.

Chemical features include dissolved oxygen, water temperature, pH and conductivity. Routine physical features include substrate, width, depth and flow velocity. Riparian vegetation and vegetative canopy for each sampling stations are included. The inventory of aquatic macroanimals is limited to those that could be seen with the naked eye. The distribution and relative abundances of these organisms are also determined. Species with sport, subsistence or commercial value as well as any rare, threatened or endangered species will be identified.

Construction, operation, and maintenance of the planned hydroelectric facility will impact the stream macrofauna. Some potential impacts are discussed and some recommendations will be made. This study does not include IFIM analysis.

SITE DESCRIPTION

Hanalei River and Valley

Hanalei River is situated in Hanalei Valley on the island of Kauai (Figure 1). The approximate coordinates of its river mouth are 22°13'05" North latitude, 159°31'01" East longitude. Its headwaters originate at an elevation of 1340m (4420 ft) and the main channel is about 25 km (15 miles) with a slope gradient (m/km) of 54 (Timbol 1977). Figure 2 shows a profile of Hanalei River.

The long term average discharge (1964-1984) for Hanalei River is 217 ft^3/s or 157, 200 acre-ft/year (Chinn, Tateishi and Yee 1985) with October and April having the highest discharge in water year 1983 and 1984. As indicated in Figure 3, the flow regime is irregular. A portion of the Hanalei surface flow has been exported since 1925 by way of the Hanalei tunnel at about 365m elevation. This is upstream of the proposed diversion weir for the Hanalei hydroelectric project. Another smaller portion is diverted by way of the Kuna and China ditches for use in the taro fields near the river mouth. Some cattle and horse pastures are located in the middle and lower Hanalei valley. Most of these pastures and two farms are within the USFWS Hanalei Wildlife Refuge. Native waterbirds are abundant in the refuge. The alien bird, cattle egret (*Bubulcus ibis*) is also seen flying in and out of the valley.

Hanalei River is one of the few streams which support an ethnic (goby) fishery. For example, during one freshet day (August 13, 1986), the 'o'opu-nakea (*Awaous stamineus*) were on spawning migration. At eleven in the morning of the next day, I counted 49 persons pole fishing for the goby along the river banks in the vicinity of Hanalei bridge. Gill nets set to harvest the spawners numbered six: three by the rice mill, two by the Hanalei bridge and one just upstream of the Dolphin restaurant. One group of 15 pole fishers caught 11 spawners in 10 minutes.

The river is one of seven streams on Kauai in the Nationwide Rivers Inventory, a listing of the Nations significant relatively natural and free-flowing streams (The National Park Service 1982). It is described as "extremely photogenic."

Sampling Stations

Ten sampling stations were established. Three stations (Stn 1,3) are upstream of the proposed diversion weir for the hydroelectric facility; station 2 is in an unamed (Kaamaawi) tributary. Five stations (4-8) are between the proposed weir where streamflow will be diverted and the proposed powerhouse where the water will be released to the mainstream channel. Two stations (9, 10) are downstream of the proposed powerhouse. Stations 1 through 3 are referred to as upper elevation stations, 4 through 8 as middle stations and 9 and 10 as floodplain or lower elevations. Distances mentioned in the following description of sampling stations are in terms of channel lenghts measured from USGS topographic maps with a KE map measurer. Methods to obtain substrata, riparian vegetation and flow velocity mentioned in describing the sampling stations are in Materials and Methods.

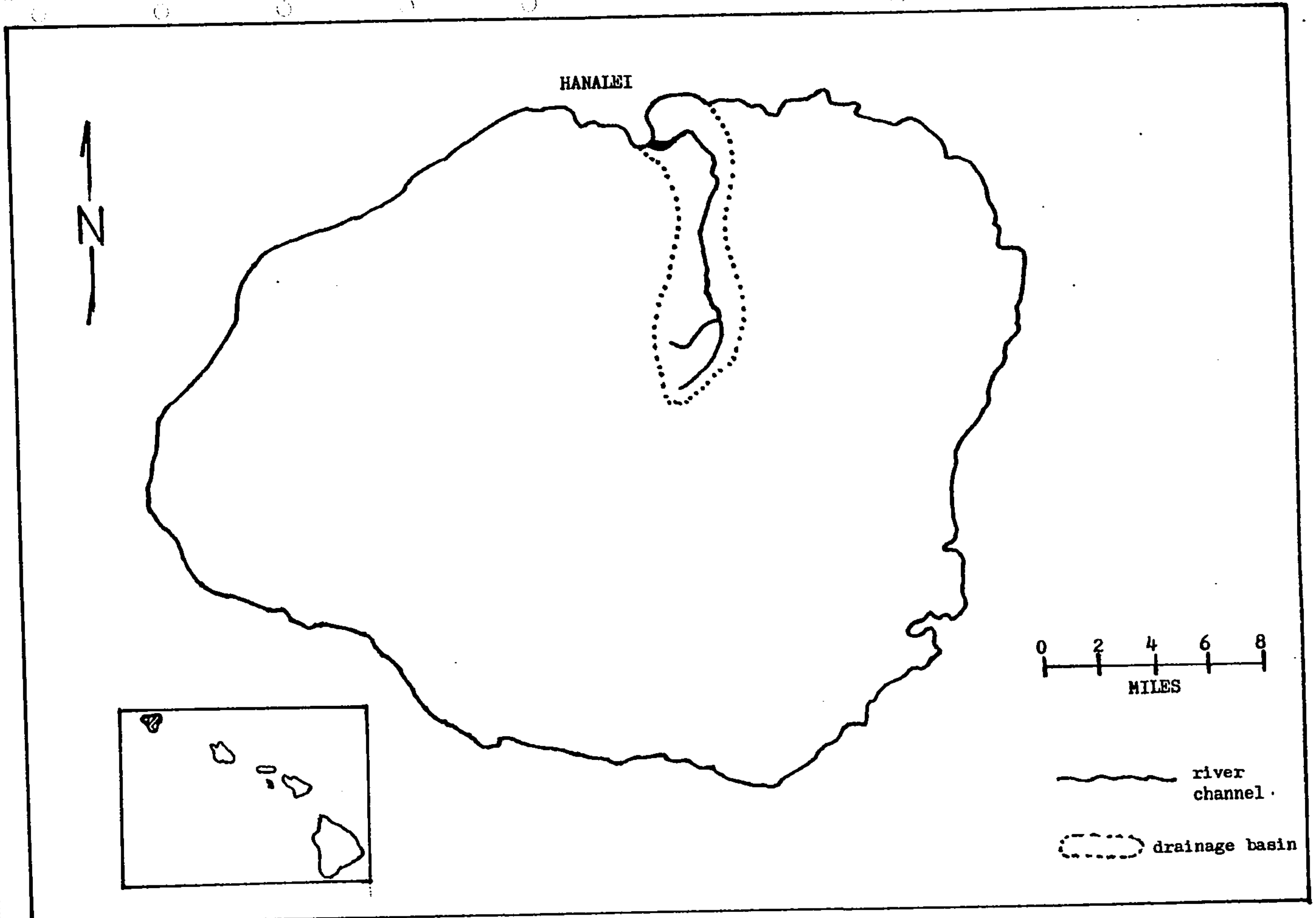

Figure 1. Location of Hanalei River on the island of Kauai.

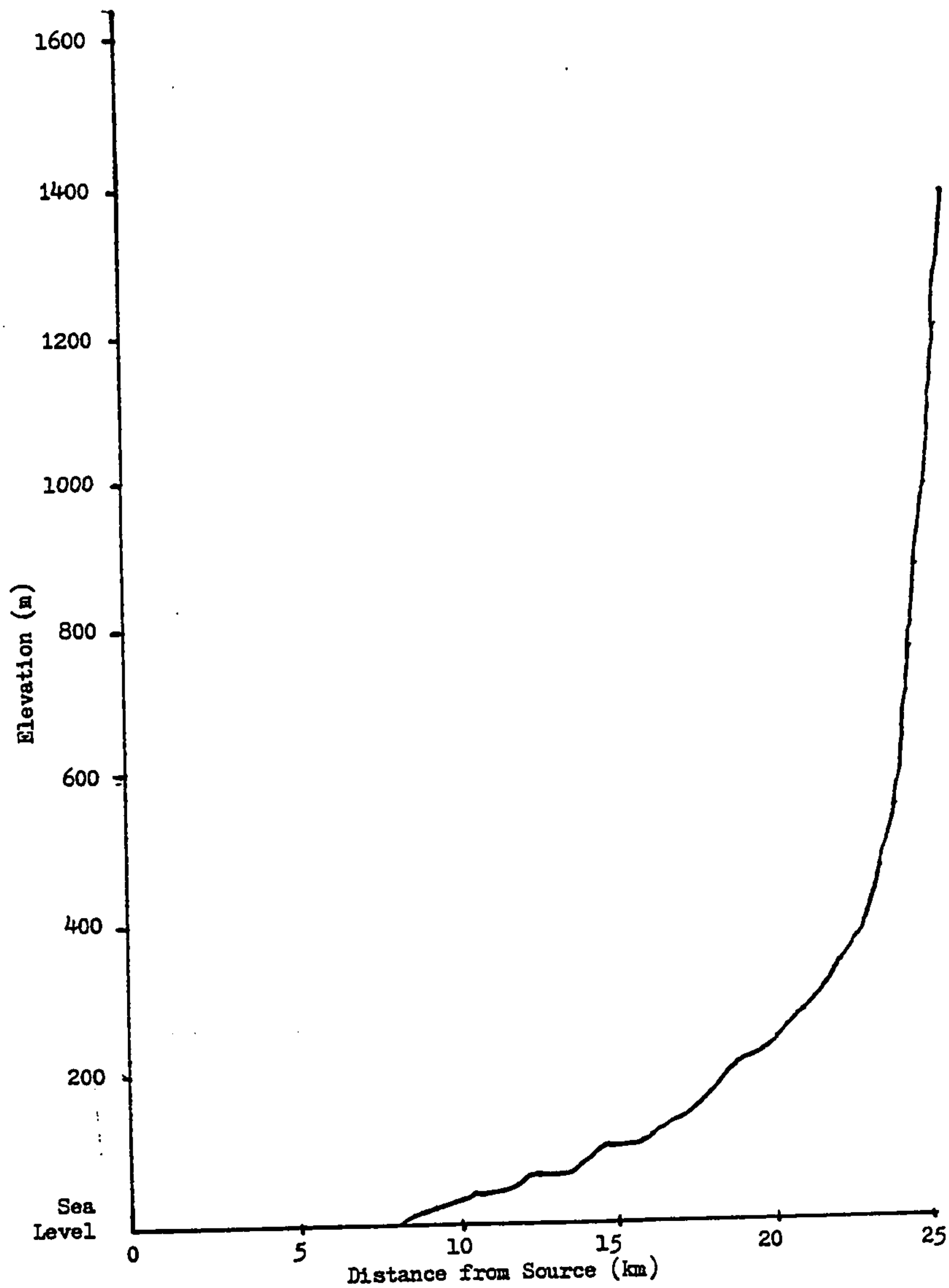

Figure 2. Profile for Hanalei River on Kauai. Slope gradient (m/km): = 54.

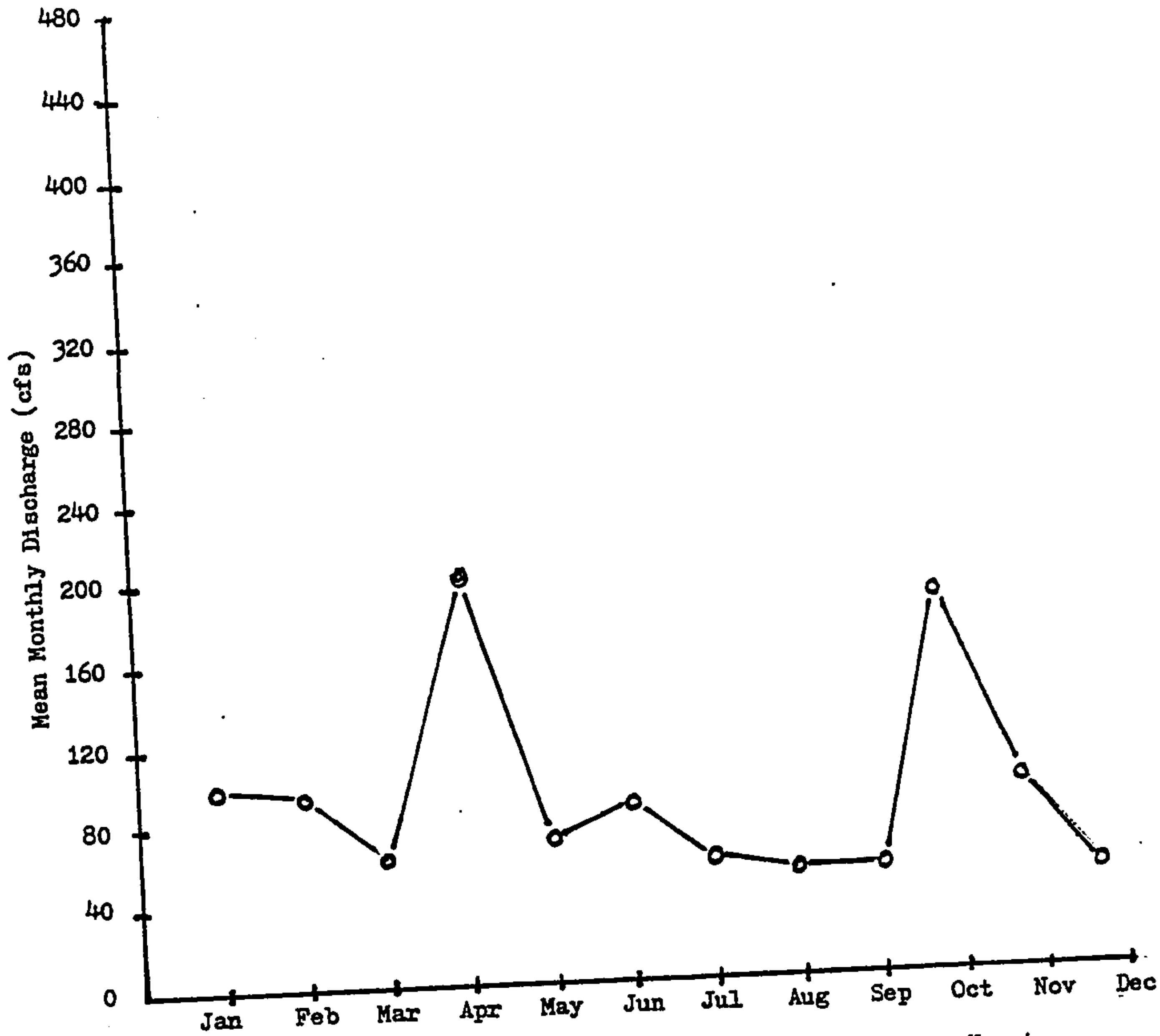

Figure 3. Monthly patterns of discharge for Hanalei River, Kauai. (Discharge data from USGS Water Data for Oct. 1983 to Sept. 1984, Chinn, Tateishi and Yee 1985.)

Station I. elev. 425m (1400 ft) Fig. 4

This station is 19 km (11.6 miles) from the river mouth. It is one of three stations located upstream of the proposed diversion weir. The stream at this station is about 4.6 m (15 ft) wide and 0.5 m (20", range 12"-22") deep and a flow velocity of 0.73 m/s. The substrate consists of approximately 60% boulder, 30% bedrock and 10% cobble. There is no vegetative canopy covering the stream. The riparian vegetation on both banks consists mostly of ohia (*Metrosideros* sp.), yellow guava (*Psidium guajava*), and a few tree ferns (*Cibotium* sp.). The ground covered is mostly ferns.

Station II. Kaanaawi tributary, elev. 415m (1360 ft) fig. 4

This tributary is not named on the USGS topographic map but we name it here after the ridge that borders the tributary. It is the second of three stations located upstream of the proposed diversion weir. The tributary is split into two channels with an island in between. Facing upstream, we sampled the left channel.

It measured about 4.6m (15 ft) wide with an average depth of 0.5m (18", range 6"-24") and a flow velocity of 0.74m/s. The stream channel is about 20% covered with vegetative canopy of yellow guava and ohia. Ground cover consists of fern with some honohono (*Commelina diffusa*).

Station III. elev. 354m (1160 ft) Fig. 4)

This station is 0.6km (0.4 mile) downstream of station 1 and the third of three stations located upstream of the proposed diversion weir. It is about 5m (17 ft) wide, 0.2m (8", range 5"-14") deep and flows 0.79m/s. The substrate is about 60% boulder, 30% cobble and 10% gravel. Facing upstream, riparian vegetation on the left bank consists of ohia trees for the upper story with fern and Ti plants (*Cordyline terminalis*) as ground cover. The right bank consists of yellow guava trees for upper story and uluhe fern for ground cover.

Station IV. elev. 110m (360 ft) Fig. 4

About 4km (2.5 mile) downstream of station III, it is downstream of the proposed weir. This station is one of five stations which will be subject to dewatering. It is also one of five stations referred to as middle elevation stations. Physical dimensions are 12m (40 ft) wide, 0.5m (18", 15"-24") deep and a flow velocity of 0.75m/s. Substrate consists of about 95% boulder and 5% cobble. Riparian vegetation consists of yellow guava for upper story and California grass (*Brachiaria mutica*) for ground cover on both banks.

Station V. elev. 85m (280 ft) Fig. 4

This middle elevation station is 0.8km (0.5 mile) downstream from station IV. It is 27m (90 ft) wide and about 0.3m (12", range 6"-24") deep with a flow velocity of 1.4m/s. The substrate consists approximately of 95% boulder, 5% cobble. Riparian vegetation consists of yellow guava trees for upper story and California grass for ground cover on both banks.

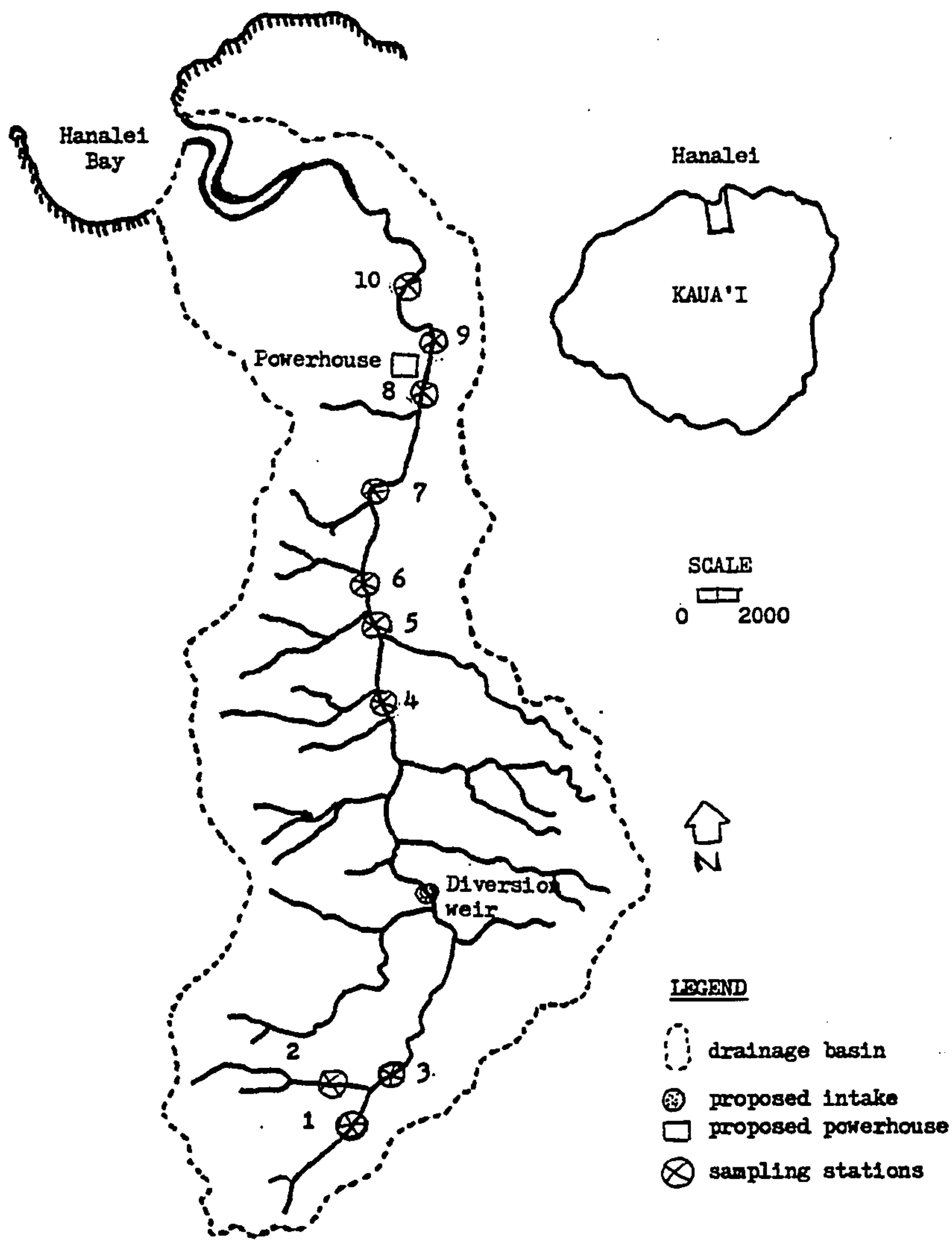

Figure 4. Study area for the aquatic macrofaunal survey of Hanalei River, Kauai. Survey area is limited to stream course outlined in black.

Station VI. elev. 61m (200 ft) Fig. 4

About 0.8km (0.5 mile) downstream from station V, this middle elevation station consists of two smaller channels around an island. Station VI is on the right channel (facing upstream). Physical measurements consists about 10m (33 ft) wide, 0.5m (20", range 18"-48") deep and a flow velocity of 1.4m/s. Substrate consists of 80% boulder and 20% cobble. Guava trees dominate the vegetation on both sides of the stream except for one large mango (*Mangifera indica*) tree on the right bank. Ground cover consists mostly of California grass, fern and a few job's-tear grass (*Coix lachryma-jobi*).

Station VII. elev. 37m (120 ft) Fig 4

This middle elevation station located in the vicinity of Puu O Miki, is some 1.9km (1.2 miles) downstream from station VI. The river channel at this vicinity splits into two and surrounds an island. Facing upstream, station VII is on the left channel. It is about 3.7m (12 ft) wide with an average depth of 0.3m (10", range 6"-24") and a flow velocity of 1.3m/s. The substrate is 80% boulder and 20% cobble. The left bank is mostly of yellow guava for the upper story riparian vegetation and California grass for ground cover. The right bank has no trees but has California grass for ground cover.

Station VIII. elev. 24m (80 ft) Fig. 4

Located 1.1km (0.7 miles) downstream of station VII, this middle elevation station is about 19m (62 ft) wide, about 0.3m (12", range 6"-24"). Water flows at 1.1m/s. The substrate consists of 50% boulder, 40% cobble and 10% gravel. Facing upstream, the riparian vegetation on the left bank consists of hau (*Hibiscus tiliaceus*), yellow guava trees with wait-a-bit (*Caesalpiniz sepiaria*) climbing over the guava trees. On the right bank, there is one large mango tree, hau and bamboo trees with California grass as ground cover.

Station IX. elev. 6m (20 ft) Fig. 4

This floodplain channel is located approximately 100m downstream of the intake for the Kunia and China ditches. This is one of two stations downstream of the proposed powerhouse. It is 1.8km (1.1 mile) downstream of station VIII. Physical dimensions are about 16m (52 ft) wide, 0.5m (20", range 15"-25") deep and a flow velocity of 0.88m/s. Substrate consists of 80% boulder and 20% cobble. Riparian vegetation on the left bank consists mostly of hau bushes and yellow guava trees with wait-a-bit vines for the upper story and California grass for ground cover. The right bank consists mostly of hau with java plum (*Eugenia cuminii*) and California grass for ground cover.

Station X. elev. 6m (20 ft) Fig. 4

Some 1km downstream of station IX, this second of the floodplain stations is situated about 7km (4.1 mile) from the river mouth. Its physical features are 20m (65 ft) width, 0.3m (12". range 6"-24") deep and a flow velocity of 1.1m/s. Substrate consists of 90% boulder and 10% cobble. The riparian vegetation on the left bank consists of hau bush for upper story and California grass for ground cover. The right bank has a few strands of haole koa (*Lucaena leucocephala*) and California grass for ground cover.

MATERIALS AND METHODS

Physicochemical

Water temperature and dissolved oxygen were determined with the use of a YSI model 57 oxygen meter. Water temperature readings were checked in the field using a hand held mercury thermometer. Conductivity was measured with a YSI model S-C-T meter. pH was determined with a Digisense model 5994 pH meter which was calibrated with standard buffer on site before each reading. All parameters were taken in situ.

Substratum data were obtained subjectively. A sampling station was examined to determined what type of substratum dominated. Designations used here are adapted from the Wentworth particle size scale (Bovee and Cochnauer, 1977, p.5) where boulder-cobble means that more than 50% of the substrata is boulder size (250-1000 mm) with cobble next in abundance. A cobble-gravel substratum signifies that cobble (between 64 and 250 mm) comprises more than 50% of the substratum with gravel next in abundance. Gravel-sand means that gravel (between 2 and 64 mm) makes up more than 50% of the substratum with coarse sand next in abundance. Sand-mud means that coarse sand (between 1 and 2 mm) was more than 50% of the substrata with mud next in abundance.

Water velocity was measured as the time that a ripe yellow guava fruit takes to travel a pre-measured 20-feet stretch. Repeated measurements were taken until three similar values were obtained. The average of these three values was used as time.

Biological

Riparian vegetation was identified in the field. Overhead vegetative cover was estimated by "eyeball."

Collection of fish and decapod crustaceans were made with battery- and generator-energized backpack electroshockers in each of the 10 sampling stations. All specimens collected from a 20m x 1m sampling zone were identified, counted, and released in the same area. Generally, electroshocking was continued beyond the 20m x 1m zone to determine if additional species were present. Species found by sampling or sighting beyond the $20m^2$ zone are included in the inventory of species. The limitations of using electroshocking as a collecting method are discussed by Maciolek and Timbol (1980), Riggs (1953), and Larimore (1961).

A small 'opae net (scissor net) was used with the electroshocker. Before shocking was started, the 'opae net was placed about a meter downstream of the area to be sampled so that stunned organisms not seen by the electroshocker operator would not be lost.

Mollusks were sampled by observation using a face mask and by feeling around boulders and collecting there within the $20m^2$ zone. These were counted, identified and released in the same area.

Bottom-dwelling insect larvae, minute snails, worms and leeches were sampled with a WIDCO Surber Stream Bottom Sampler #12-ann with 728 microns mesh size. The surber net was set downstream of a 12" frame from which the collection is to be made. Large stones were picked and organisms were washed from them into the net. After the large stones had been picked up, washed, and discarded, the remainder of the area inside the frame was gently churned to wash burrowing forms into the net. The contents of the net were preserved in formalin and taken to the laboratory where the organisms were sorted, counted, and identified. References used to identify the macrobenthos were: Williams (1936), Zimmerman (1948), and Cowles (1977) for insects and Hubendick (1952) for Hawaiian pond snails.

Macrofauna are reported in a semi-quantitative basis. In this report, abundant (+++) means many specimens were obtained in a collection, from 6 to 100 or more. Common (++) indicates that the species was obtained in numbers between two and five. Uncommon means that only one specimen was collected in the sampling zone or was sighted only. Absent (0) indicates that none was obtained or sighted in the sampling station.

Terms used in designating the origin of animals are: endemic, means occuring naturally in Hawaii only; indigenous, means occuring naturally in Hawaii and also elsewhere; alien, means that the animal was brought to Hawaii either intentionally or accidentally; and native, includes both endemic and indigenous animals.

Additional terms include diadromous, a designation for species which are migratory between fresh and salt water. This behavior involves sexually mature fishes breeding in fresh water, passive downstream passage of eggs or larvae to the ocean during freshet flow with later active upstream migration. A species has economic value if it has sport, recreational, subsistence or commercial value.

Endangered species means a species which is in danger of extinction throughout all or a significant portion of its range (Deacon, et al. 1979). Depleted indicates that the organism is still found in numbers adequate for survival but has been heavily depleted and continues to decline substantially (Miller 1972). Rare means uncommon, occurs in small numbers. Special concern species are those that could become threatened or endangered by relatively minor disturbances to their habitat or that require additional information to determine their status (Deacon, et al. 1979). These definitions do not have legal status under the Federal Rare and Endangered Species Law.

The list of biota was checked for endangered and threatened species using the following list and scientific publication: Miller (1972), USFWS List of Endangered and Threatened Species (1977) and Deacon et al. (1979). Native (Hawaiian) names come from Pukui and Elbert (1971).

RESULTS AND DISCUSSION

Physicochemical

These one-time, one season data reflect only the conditions at the time of sampling. They may be useful for comparative purposes and could be part of the pre-construction data if the proposed project is realized. Long-term physicochemical data for the river are available in USGS Water Data for Hawaii (Chinn, Tateishi, and Yee 1985).

Subsurface water temperature in the 10 sampling stations ranged from 18 - 24°C (Table 1). Stations at the upper elevations were about 4°C cooler than the flood plain stations. This range falls within the range of unaltered streams studied by Timbol and Maciolek (1978) and are within the tolerance of native gobies (Hathaway 1978).

Conductivity indicates total dissolved solids in water (Cole 1979). In Hanalei, conductivity ranged from 53 through 83 umhos (Table 1). The upper elevation stations have lower conductivity than the flood plain stations. The values are indicative of water with very low dissolved materials. These values are lower than those for Kauai streams which included farms within their drainage areas (Timbol and Maciolek 1978).

Results for dissolved oxygen were obtained as mg/L and converted to per cent saturation (Table 1). Hanalei River water is well saturated with oxygen, from the upper elevations through the middle elevations down to the flood plain stations. These results are indicative of clean, strong flowing, bubbling waters.

The pH of Hanalei River is between 7 and 8 (Table 1); well within the range of neutral to slightly alkaline water for normal Hawaiian streams. Organic acids from decomposing plant materials in the water shed tend to make stream water more acidic but is probably neutralized as the water flows over volcanic rock.(Bright 1982).

Biological

The macrofaunal component of Hawaiian stream biota is composed of species which are readily recognizable and can be collected or enumerated by established methods. The planned construction and operation of a hydroelectric facility in Hanalei valley requires that emphasis should be given to the endemic diadromous organisms. A more extensive discussion on Hawaiian stream fauna is available in Timbol (1977). Diadromous animals are those that spend their entire adult life in fresh water: but their larvae must reach the ocean to develope and re-enter streams as post larvae. To this group belong all the native freshwater gobies, the endemic mollusk hihiwai, and the endemic mountain shrimp, 'opae-kala'ole. The alien Tahitian prawn is also diadromous.

The life history of the 'o'opu-nakea is a good illustration of diadromy in Hawaiian streams. This endemic goby had been studied by Ego (1956) and its life cycle is illustrated in Timbol and Heacock (1986). In August through December, the 'o'opu-nakea migrate downstream and deposit their eggs on stones near the mouth of streams. The eggs hatch within a day and the larvae are carried out to sea by water current where they spend between 5 and 7 months as part of the marine zooplankton. They then return to stream mouths and start upstream migration to their places of permanent residence where they attain sexual maturity.

Table 1. Physicochemical features of Hanalei River, Kauai and its Kaanaawi tributary (September - October 1986).

	PARAMETERS			
	Water Temp. (°C)	Conductivity (mhos)	Diss. Oxygen (% sat.)	pH
Sampling Station I	18.5	62	103	7.35
Sampling Station II	18.2	62	101	7.35
Sampling Station III	18.0	70	100	7.57
Sampling Station IV	24.0	75	100	7.77
Sampling Station V	23.0	80	100	7.95
Sampling Station VI	24.0	53	100	7.91
Sampling Station VII	23.0	63	100	7.44
Sampling Station VIII	24.0	80	101	8.01
Sampling Station IX	23.5	83	102	7.35
Sampling Station X	24.0	82	99	7.39

Species Inventory

At least 25 species of macrofauna were found in Hanalei River and a tributary, Kaanaawi. The organisms include two annelids, six insects, two mollusks, three crustaceans, ten fishes and two amphibians. The scientific and local names, their origin and their listing are summarized in Table 2. Twelve species are endemic, two are indigenous, eight alien and two are of unknown origin. Six of the endemic species, one indigenous fish, one alien crustacean and one alien fish have some economic importance. The most valuable is the endemic goby, Awaous stamineus ('o'opu-nakea) since it supports a minor ethnic fishery.

Compared with an earlier study (Timbol 1977, p. A-7) this 1986 survey lists six more species. The number is not significant. The 1977 study does not include the earthworm and the two species of amphibian tadpoles. Another insect larva may also have been there in 1977 but was not recognized. The significant difference between the two studies is the presence of the endemic goby, Letipes concolor ('o'opu-alamo'o) and the mosquitofish, Gambusia affinis. It is highly probable that the 'o'opu-alamo'o was also present in 1977 but was not collected. That it was collected this time reflects on the collectors' improved skill on electroshocking techniques and increased awareness where the 'o'opu-alamo'o might be collected in a stream. As for the alien mosquitofish, it may have established itself after 1977 or it may have been already there in 1977 but in very low numbers to have been missed at that time.

Lentipes concolor

o'opu alamo'o

Of the 25 resident species, only four (all endemics) are listed in scientific publications as depleted and/or special concern. These are the endemic mollusk, hihiwai (Neritina granosa), and three endemic gobies; 'o'opu-nakea, 'o'opu-alamo'o, and 'o'opu-nopili (Sicyopterus stimpsoni). The first two species are sometimes sold commercially. None, however, is listed as rare or endangered under the Federal Rare and Endangered Species Law. Capsule life histories of these four are shown below.

1) Neritina granosa (hihiwai)

This diadromous Hawaiian endemic grows to 6cm shell diameter and the largest endemic neritid. It prefers clear water, bouldery, steep gradient streams. As in the diadromous gobies, the hihwai breeds in fresh water, the larvae are swept passively to the ocean where they undergo transitional larval developement as marine plankton. They reappear at stream mouths as prejuveniles and migrate upstream. Extensive information regarding the biology of the hihiwai is in Ford (1979).

During this study, we found only prejuveniles (1-3mm diameter) in the higher elevation stations 1 and 2. Don Heacock, DLNR Aquatic Biologist on Kauai (personal communication, Dec. 19, 1986) found three larger specimens sometime in 1985 "after hours of looking for them" at a middle elevation station (station 7, 37m elevation).

The hihiwai has been utilized for food since early Hawaiian days and is still harvested commercially. These snails are occasionally sold in supermarkets in size averaging 25mm shell diameter (range 15-30mm). According to Ford (1979, p.57) a 15mm hihiwai weighs about 0,5 gram and a 30mm about 2.45grams. The last reported price was $5.99/lb at Big Save in Kapaa on August or September 1982 (Don Heacock, verbal communication, December 19, 1986). Maciolek (1978) considers this neritid snail as depleted.

2) Awaous stamineus ('o'opu-nakea)

This is the largest of the endemic gobies, reaching a minimum of over 30cm standard lenght (SL) in Kauai streams. In Hanalei, our samples ranged between 2 and 33cm SL. Ego (1956) reported them in Wainiha River as far inland as 11,000m (36,090 ft) at 450m (919 ft) elevations with greatest densities at between 3,000 and 5,000m (9843-16,405 ft) from the stream mouth.

Table 2. List of aquatic macrofauna in Hanalei River and Kaanaawi tributary, island of Kauai. (September - October 1986)

Scientific Name	Local Name	Origin[1]	Listing[2]
Annelids (worms)			
Hirudinea	leech	unknown	none
Oligochaeta	earthworm	unknown	none
Insects			
Diptera:			
Chiromonidae	midge larvae	endemic	none
Ephydridae	brinefly larvae	endemic	none
Tipulidae	cranefly larvae	endemic	none
Odonata:			
Megalagrion heterogamius	damselfly naiad	endemic	none
Trichoptera:			
Cheumatopsyche analis	caddisfly larvae	alien	none
Oxyethira maya	microcaddisfly larvae	alien	none
Mollusks (snails)			
Erinna aulacospira	pond snail	endemic	none
Neritina granosa[3]	hihiwai	endemic	depleted on Oahu (Maciolek 1978)
Crustaceans (prawns and shrimps)			
Atya bisulcata[3]	'opae-kala'ole	endemic	none
Macrobrachium grandimanus[3]	'opae-'oeha'a	endemic	none
Macrobrachium lar[3]	tahitian prawn	alien	none
Fishes			
Awaous genivittatus	'o'opu-naniha	indigenous	none
Awaous stamineus[3]	'o'opu-nakea	endemic	special concern (Deacon, _et al_. 1979); depleted (Miller 1972)
Eleotris sandwicensis[3]	'o'opu-okuhe	endemic	none
Gambusia affinis	mosquitofish	alien	none
Kuhlia sandvicensis[3]	aholehole	endemic	none
Lentipes concolor[4]	'o'opu-alamo'o	endemic	special concern (Deacon, _et al_. 1979)
Mugil cephalus[3]	ama'ama, mullet	indigenous	none
Sarotherodon mossambica[3,5]	tilapia	alien	none
Sicyopterus stimpsoni	'o'opu-nopili	endemic	special concern (Deacon, _et al_. 1979)
Xiphophorus helleri	swordtail	alien	none
Amphibians (frogs)			
Rana catesbeiana	bullfrog tadpoles	alien	none
Rana rugosa	greenfrog tadpoles	alien	none

1 Terms used in this column: endemic = occuring naturally in Hawaii only; indigenous = occuring naturally in Hawaii and also elsewhere; alien = brought to Hawaii either intentionally or accidentally by man.
2 Considered as endangered or threatened in official register or scientific publications.
3 Has some economic use.
4 Recommended for recognition as endangered (Maciolek 1977).
5 _Tilapia melanopleura_ is known to be established in Kauai streams also.

This species is well known for downstream migrations usually in association with freshets or flash floods. Spawning occurs near the mouth of rivers and streams. It requires between 0.00 and 0.45 ft/s with optimum at less than 0.6 ft/s and depth optimum at about 1.6 ft (Kinzie, et al. 1984). The 'o'opu-nakea is sometimes sold commercially, the last sale at Kapaa Big Save was in September 1986 at $9.89/lb.

3) Lentipes concolor ('o'opu-alamo'o)

The 'o'opu-alamo'o is the rarest of the Hawaiian stream fishes (Maciolek 1977, Lau 1973). In the Hawaiian folklore, to find 'o'opu-alamo'o in a net when fishing for other fish is bad luck for it keeps other fish away. This fish is regarded as kapu (forbidden) by Hawaiians who believe it is related to the Mo'o (lizard gods) (Titcomb 1972).

'O'opu-alamo'o which grows up to 10.0cm (Lau 1973) is an almost scaleless fish which exhibits sexual dimorphism. During breeding season, the male is jet black anteriorly and bright red-orange posteriorly. Females exhibit only brown color on its entire body. Although this fish is diadromous, there is evidence that it does not undergo downstream migration for spawning purposes (Nishimoto and Fitzsimmons 1986). This goby requires a flow velocity between 0.00 and 0.31 ft/s with optimum at less than 0.5 ft/s and depth below 1.5 ft (Kinzie et al. 1984).

4) Sicyopterus stimpsoni ('o'opu-nopili)

This small (up to 15cm SL) diadromous endemic goby also exhibits sexual dimorphism. The males are dark olive-gray or nearly black and the females blue-green to blue-grey. In early Hawaiian days, the 'o'opu-nopili was greatly relished for food, and was a favorite fish with the priests. It is also considered to bring good luck (Titcomb 1972). According to Titcomb (1972) the largest 'o'opu-nopili (up to 18 cm SL) were found in Kauai streams, particularly in Wainiha, Hanalei and Makaweli. During this survey, the specimens we caught ranged between 2 and 15 cm SL.

This species has been recommended by Timbol and Maciolek (1978) as an indicator species. Its decline in population density, or in extreme cases, its disappearance from a stream is a good indication of serious stream degradation. The 'o'opu-nopili requires 0.95 and 1.25 ft/s flow velocity with the best at less than 0.7 ft/s and depth at less than 1.5 ft (Kinzie et.al. 1984). Extensive information on the biology of the 'o'opu-nopili is available in Tomihama (1972).

Distribution and Relative Abundances

The purpose of semiquantitative sampling is to determine the relative abundance of each species in a standardized manner so that the seasonal and temporal changes in numbers can be measured. Table 3 summarizes the distribution and relative abundances of macrofauna collected in the river.

Not all 25 species found in Hanalei River are found in all stations. There are lesser number of species at the upper stations and the number increases (9 to 16) as one proceeds downstream to the floodplain. Five species are found in 9 or all 10 stations. These are: two alien insect larvae (Cheumatopsyche and Oxyethira), one endemic insect larva (Chiromonidae), one endemic shrimp ('opae-kala'ole); two endemic gobies ('o'opu-nakea and 'o'opu-nopili). With minor exceptions, all five ubiquitous species were abundant. A seventh species, the amphibian Rana rugosa tadpole may be present in all stations although we have not collected them in stations 1, 7 and 10 at this time.

The insect macrofauna component consists mostly of Cheumatopsyche, Oxyethira and Chiromonidae larvae. Insect larvae are very important

Table 3. Distribution and relative abundances of aquatic macrofauna in Hanalei River and Kaanaawi tributary, island of Kauai. (September - October 1986)

Scientific Name	Sampling Stations									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Annelids (worms)										
Hirudinea	0	0	0	+	0	0	+++	++	0	++
Oligochaeta	0	0	0	0	0	+	0	0	0	+
Insects										
Diptera:										
Chiromonidae	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Ephydridae	0	+	+	+	0	0	0	++	+++	+++
Tipulidae	0	+	+	0	0	0	+	+++	0	0
Odonata:										
Megalagrion heterogamius	+++	++	++	0	0	0	0	0	0	0
Trichoptera:										
Cheumatopsyche analis	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Oxyethira maya	+++	+++	+++	++	++	+++	++	+++	++	+++
Mollusks (snails)										
Erinna aulacospira	+	0	0	0	0	0	0	0	0	0
Neritina granosa	++	+	0	0	0	0	0	0	0	0
Crustaceans (prawns and shrimps)										
Atya bisulcata	+++	+++	+++	+++	+++	+++	+++	++	++	+++
Macrobrachium grandimanus	0	0	0	0	0	0	0	+++	+++	+++
Macrobrachium lar	0	0	0	++	++	++	++	+++	++	+++
Fishes										
Awaous genivittatus	0	0	0	0	0	0	0	0	++	++
Awaous stamineus	++	+++	+	++	+++	+++	+++	+++	++	++
Eleotris sandwicensis	0	0	0	0	+	0	0	0	+++	++
Gambusia affinis	0	0	0	0	0	0	0	+++	0	0
Kuhlia sandvicensis	0	0	0	0	0	0	0	0	+++	+++
Lentipes concolor	0	0	+	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	++	++	++
Sarotherodon mossambica	0	0	0	0	0	0	0	0	++	0
Sicyopterus stimpsoni	++	++	++	+	+++	++	++	+++	0	0
Xiphophorus helleri	0	0	0	++	++	0	0	0	+++	++
Amphibians (frogs)										
Rana catesbeiana	0	0	0	0	0	0	0	++	++	+++
Rana rugosa	0	+	+++	+++	+++	+++	0	+++	++	0

Abundances: +++ = abundant; ++ = common; + = uncommon; 0 = absent or not seen. Refer to methods and materials section for numerical equivalences.

intermediaries in the utilization of plant materials and recycling of nutrients in aquatic environments. They are a major food source for fish and they may be used to determine the well-being of those fish populations. According to Platts, Megahan and Minshall (1983) insect larvae are useful for determining environmental disturbances because they have limited mobility and therefore will reflect conditions in the immediate vicinity. Insect larvae also have short life span. Their characteristics are a function of conditions during the relatively recent past.

The mollusks component of the macrofauna were found only in the upper stations during this study. They were not found in large numbers. The economically important neritid mollusks, hihiwai, has been discussed in the preceding section.

The crustacean component consists of three species: two endemics and one alien. All three have some economic values. The endemic shrimp 'opae-kala'ole, is abundant in all 10 stations. They are largest (mostly adults) in the upper stations, medium size (young adults and juveniles) and very small (mostly postlarvae and juveniles) in the floodplain stations. This shrimp is harvested by local residents for food. The second endemic crustacean, 'opae-'oeha'a, is found in abundance in the flood plain stations and was absent in the middle and upper stations. It is gathered for use as bait. The third crustacean, the alien Tahitian prawn, is found only in the middle and flood plain stations. They are found in lower abundance as compared with 'opae-kala'ole and 'opae-'oeha'a but since the Tahitian prawns are very much larger than the first two, the Tahitian biomass is significant. Tahitian prawns are harvested by local residents for food.

The fish component of the macrofauna is the most significant because of the endemicity and commercial value of the 'o'opu-nakea. This endemic, economically important goby was found in all but the highest of collecting stations (station 1). It is found in greater numbers in the middle sampling stations than in the upper and flood plain stations. This distribution and abundance is the same as that found in Wainiha River (Ego 1956); higher abundance in the lower elevations. The 'o'opu-nopili can be found in all the stations except those in the flood plain stations. The 'o'opu-alamo'o was found only in the upper elevations, upstream of the proposed diversion weir for the hydroelectric facility but downstream of the existing Hanalei ditch diversion weir. This is the first time that the 'o'opu-alamo'o has been caught in Hanalei. That only one was caught (in station III) confirms the earlier findings of Lau (1972) and Maciolek (1977) that this goby is the rarest of the Hawaiian endemic stream gobies.

The amphibian component of the macrofauna consists mainly of tadpoles. The almost ubiquitous _R. rugosa_ tadpoles is probably a food organism for fish. The adult has no economic value. The bullfrog tadpoles, _R. catesbeiana_, has been found only in the floodplain stations. The adults can be heard croaking along the banks. The bullfrog is a desired food organism but local residents claim that there are not enough in the area to justify time spent in collecting them except once in a long while.

POTENTIAL IMPACTS AND MITIGATION

A pristine Hawaiian stream is an aggregate of bubbling brooks that have not been physically and biologically changed by human intervention (Maciolek 1975, p.8). Each of these brooks is visualized to have a complement of native species. The latest statewide inventory of streams (Timbol and Maciolek 1978) showed that no such stream exists today. A few streams show some signs of pristinity and many students of Hawaiian environment believe that Hanalei River is one of these. The construction, maintenance and operation of a hydroelectric facility in Hanalei Valley will have several potential impact on the river biota. For purposes of discussion, they are divided into four groups:

1) Blockage of fish migration
2) Loss or degradation of habitat
3) Change in the amount and pattern of instream flow
4) Mortality and morbidity of fish passing through turbines
5) Degradation of water quality

1. <u>Blockage of Fish Migration</u>

The proposed diversion weir on the main channel as well as the several diversion weirs on the tributaries could become physical barriers to the upstream migration of spawning adult 'o'opu-nakea and passive downstream passage of eggs and larvae of other native animals (i.e. 'opae-kala'ole). No study has been made on the effects of diversion weirs on migratory native Hawaiian fishes, crustaceans and mollusks. Similar installations have reduced or eliminated migratory fish populations in many drainage basins on the U.S. mainland (Baxter 1977).

Mitigative measures include adequate water flow over the weirs at all times. How much flow is adequate has not been established although 12 cfs has been suggested for the flood plain channel (Wilson Okamoto and Associates 1979) and 36 cfs was suggested for the upper elevation main channel (Timbol and Heacock 1986). In addition to adequate flow, it is suggested that the downstream face of the weir should be sloping (1:4 slope) and be covered with river rocks. This design can facilitate the upstream movement of post-larval 'o'opu and other organisms. Several forms of fish-passage structures to facilitate fish migration are discussed by Gloss and Wahl (1983).

2. <u>Loss or Degradation of Habitat</u>

The diversion of stream flow will result in the alteration of water level and flow regime in channels below the diversions and before the powerhouse where the diverted water is returned to the main channel. The lowering of water level will lead to a loss of fish and other macrofauna habitat. This will diminish the biological "carrying capacity" of the river.

Periodic exposure of the channel margin may eliminate algae, aquatic macrophytes, and riparian vegetation (Kroger 1973). Loss of algae and other vegetative materials reduces the food supply for grazing insects and fish and eliminates cover for these animals.

There are no mitigative measures for loss or degradation of habitat except to maintain an adequate instream flow.

3. Change in Amount and Pattern of Instream Flow

Two types of diversion are present in Hawaii's streams. The first type is complete diversion of surface flow. This leads to a depletion of native fishes, crustaceans and mollusks upstream of the diversion. For example, four west Maui streams (Honokowai, Kahoma, Kauaula, and Waikapu) do not have any native migratory fishes, crustaceans and mollusks above their diversions (Timbol and Maciolek 1978, p.93, 95-97). The second type, partial diversion, results in simultaneous modification of environmental conditions such as reduction of instream flow, changes in flow velocity, composition of substratum, excessive sedimentation, and high turbidity among others.

Reduction of flow could lead to fish being stranded in the dewatered stretches of stream channels. The impact of predators such as the Tahitian prawns on the economically desirable 'o'opu-nakea will have a greater impact when they are concentrated in pools. In addition, native gobies prefer strongly flowing water (Kinzie et al 1984).

Reduction in flow reduces the scouring capacity of the stream. The resulting instream flow may not be enough to flush the accumulated organic debris and suspended sediment coming from construction and maintenance activities. This will lead to turbid water, reduced visibility and clog gills (Lloyd, Rochester and Farr 1984). If sedimentation is heavy it will cover the bottom with dense layer of mud which could smother bottom invertebrates.

The impact can be substantially reduced by maintaining adequate instream flow. The work of Kinzie et al. (1984) should be consulted since it deals with the native fishes in Hawaiian streams. An earlier study (Department of Health 1977) suggested that diversion may be limited to allow 50% of the lowest instantaneous flow on record in summer, and 30% in winter and that a 10% lower limit should apply at all times. A scheme for U.S. mainland streams (Tenant 1976) suggested 10% of the average flow is a minimum instantaneous flow which will sustain short-term survival habitat for most aquatic forms; 30% will sustain good survival conditions for most aquatic life forms and general recreation; and 60% will provide an excellent and outstanding condition for most aquatic life forms during their primary periods of growth and for the majority of recreational users.

4. Mortality and Morbidity of Fish Passing Through Turbines

Fish and crustaceans can be entrained in penstocks and turbines can injure and kill them. Eggs and early larval stages are particularly vulnerable to entrainment (Boreman 1977). The U.S. Army Corps of Engineers (1960) determined that if the penstock contained air, salmon fingerlings become acclimated to increased pressure, and they may be killed when the water is released. In addition, entrained macrofauna are killed instantaneously as they hit turbine blades or sustain injuries from which they eventually succumb (Rochester, Lloyd and Farr 1984). Delayed mortality is due to stress, physiological deterioration and increased predation. Furthermore, since migratory species orientation is positively rheotactic, flow releases at the proposed power plant could result in the entrainment of migratory juveniles (Boreman 1977).

Although hydroelectric facilities have been in operation for decades (Wainiha hydroelectric since 1906), the effects of penstock entrainment and passage through turbines on any of the native organisms have not been studied.

Mitigative measures include fish screens installed at both the upstream diversion sites and the point of water re-entry into the mainstream below the hydropower plant turbines.

5. Degradation of Water Quality

Reduction in instream flow caused by diversion and removal of riparian vegetation could mean higher water temperatures. Operation of vehicles and machines during the construction phase could lead to petrochemical pollution.

The effects of elevated temperatures can be lethal, metabolic and behavioral. Lethal temperatures make up the range within which the animal will die. Hathaway (1978) studied the effects of elevated temperatures on 'o'opu-nakea and 'opae-kala'ole. He found that adult 'o'opu-nakea died in water temperatures between 37°C and 39°C and post larvae at 39°C. The adult 'opae-kala'ole died at 34°C and the post larvae at between 35°C and 36°C. Metabolic effects are "delayed effects" as in growth acceleration resulting in the inability to reach and/or pass a critical point in the animal's life cycle (Andrewartha and Birch 1954). Brown trout stopped growth above a certain temperatures and this could be due to respiratory requirements (Fry 1957). Behavioral effects are the organism's response to the environment. A motile animal will leave an area when conditions become unfavorable and will not voluntarily remain in the area until conditions become lethal. This is supported by Timbol and Maciolek's (1978, p.57-58) work on altered and unaltered streams. The streams with low water temperatures harbored more native species than streams with high water temperatures.

The other probable cause of water quality degradation is chemical pollution from materials and vehicles during construction, maintenance and operation of the proposed hydroelectric facility. Other chemicals likely to pollute the land or find their way into streams includes fuels, lubricants and paints.

Mitigative measures include proper timing and effective maintenance to ensure that other mitigative measures (e.g. fish ladders and instream flow control) are working properly. If maintenance is effective, future problems that may require extensive construction usually are identified early enough so that plans for appropriate mitigations can be made.

RECOMMENDATIONS

In addition to the mitigative measures discussed in the preceding section, three other recommendations are made. First, there is a plan to construct an access road from the existing road at Hanalei homestead to the proposed diversion weir. This road should be situated as far away as possible from the main channel. The resulting vegetative buffer zone between the access road and the river will help reduce sedimentation, water turbidity and chemical pollution. When the construction phase is over, it would be very desirable to plant-over this access road with native vegetation common in the valley. Future routine maintenance could be accomplished by hiking or helicopter transport. As discussed in the preceding section, effective maintenance will prevent future extensive repairs.

Second, the construction, maintenance and operation of the proposed hydroelectric plant will more than likely affect the 'o'opu-nakea fishery in Hanalei River. U. S. mainland procedures call for replacing lost wild fish stocks with hatchery-reared fish (Rochester, Lloyd and Farr 1984). The production of 'o'opu nakea fingerlings in hatcheries and their release in the wild to replenish lost stocks has a great potential as a mitigative measure. Funds should be appropriated by the owners of the hydroelectric facility to help develope the necessary hatchery techniques for raising 'o'opu-nakea.

Lastly, a thorough multi-seasonal stream macrofauna survey should be conducted on Hanalei River, before constructing the hydroelectric facility. A similar condition has been set by the DLNR on the second hydroelectric unit for Wainiha River, the next valley to Hanalei.

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APPENDIX II

BOTANICAL SURVEY HANALEI RIVER HYDROELECTRIC PROJECT HANALEI DISTRICT, ISLAND OF KAUA'I BY WINONA P. CHAR, NOVEMBER 1986.

BOTANICAL SURVEY
HANALEI RIVER HYDROELECTRIC PROJECT
HANALEI DISTRICT, ISLAND OF KAUA'I

by

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Prepared for: ISLAND POWER CO., INC.

November 1986

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BOTANICAL SURVEY

HANALEI RIVER HYDROELECTRIC PROJECT

HANALEI DISTRICT, ISLAND OF KAUA'I

INTRODUCTION

Island Power Company, Inc., has filed a conservation district use application for a 6.0 MW hydroelectric project with accessory uses along the Hanalei River. The project will be operated on a run-of-the-river basis.

The company proposes to divert water from the Hanalei River by means of a concrete diversion weir approximately 10 ft. high, at an elevation of 650 ft. above MSL. The water will be conveyed through an above ground pressure penstock approximately 26,600 ft. long, varying in diameter from 42 to 56 in. Additional diversion of water will also be made from several of the larger tributaries to the Hanalei River on its westerly side. The proposed penstock will route the water to a powerhouse which will be situated on the westerly bank of the Hanalei River and will discharge the water back into the river just upstream of the China Ditch Diversion at approximately 50 ft. elevation. A new above ground 69 KV transmission line, approximately 4,200 ft. long, will interconnect to the existing Kauai Electric Transmission Line near the Hanalei Homesteads. A new access road, approximately 12 ft. wide along the penstock route, will allow access from the existing road near the Hanalei Homesteads to the diversion weir.

The conservation district use application will require the preparation of an Environmental Impact Statement (EIS).

A botanical survey of the project area was conducted to (1) describe the major vegetation types; (2) inventory the flora; (3) search for rare, threatened, or endangered species; and (4) identify areas of potential environmental problems or concerns. The findings from this survey will be incorporated into the EIS.

SURVEY METHODS

Prior to undertaking the field surveys, a search was made of the pertinent literature to familiarize the principal investigator with previous studies conducted in the general area.

A reconnaissance survey trip with project personnel was made on 01-02 February 1986 to familiarize the investigator with the proposed penstock route and location of diversion weirs (intake sites). The entire penstock route, as well as the area well above the project site (up to 1,200 ft. elevation), was surveyed by foot. More intensive botanical surveys of the project site were conducted later in June and October 1986.

Access onto the upper portions of the site was made by helicopter. The primary means of surveying the site was by foot over a pig hunter's trail which follows the river along its banks. The trail follows the penstock alignment in some places.

A walk-through survey method was employed. Notes were made on the vegetation types present within the project site. A visual estimate of abundance was made for each species within each of the different vegetation types. Species which could not be positively identified were collected for later determination in the herbarium and laboratory. The species recorded are indicative of the time and environmental conditions under which the survey was conducted. A survey taken at a different season and under varying environmental conditions would no doubt yield slight variations in the species list.

DESCRIPTION OF VEGETATION

To our knowledge, there have been no flora studies that have dealt specifically with the project site. Certain taxa from the Hanalei area are represented by collections in the Bishop Museum and University of Hawaii, Manoa, herbaria. The Hanalei area has also been cited as a collection location in a number of monographs and other taxonomic literature (Degener and Degener 1932 et seq., Hillebrand 1888, Sohmer 1977, Yuncker 1934, etc.). A general description of the vegetation found in the lower portion of the project site (from the end of 'Ohiki Road to the area below Pu'u o Miki) is presented by Hume (1986).

During this survey seven major vegetation types were recognized on the study site and are discussed in detail below. Criteria such as structure, composition, and associated plant species were used in identifying and describing each of the different vegetation types.

1. Streamside Vegetation

A band of vegetation composed mostly of various wetland species of grasses and ferns, as well as a number of herbaceous species, is found along the river at the water's edge. This area is subject to periodic inundation and the turbulent flood waters often sweep away some of the vegetation. The band of vegetation may be absent or very sparse where the river is narrow and runs swiftly. It is broadest and most dense where the river is wide and runs slowly.

In the lower portion of the project site -- the area below Pekoa Falls -- Californiagrass (Brachiaria mutica) is the most abundant component of the streamside vegetation. Other species which are common in these Californiagrass dominated areas include large crabgrass (Digitaria ciliaris), downy wood fern (Christella dentata), Hilo grass (Paspalum conjugatum), and honohono (Commelina diffusa). Locally common are patches of Job's tears (Coix lachryma-jobi).

In the upper portions of the project site, Californiagrass is gradually replaced by Job's tears and neke (Cyclosorus interruptus), a native fern.

Scattered plants of kamole (Ludwigia octivalvis), puakamoli (Cuphea carthagenensis), drymaria (Drymaria cordata), honeywort (Cryptotaenia canadensis), Pycreus polystachos, taro (Colocasia esculenta var. antiquorum), Glenwoodgrass (Sacciolepis indica), and pohekula (Centella asiatica) are often encountered in the streamside vegetation.

A few small saplings and seedlings of the tree and shrub species from the surrounding forests are also encountered. Most of these plants, however, are swept away during periods of heavy rain.

2. Mixed Introduced Forests

In the area from the homestead lands to Pu'u o Miki, the vegetation is dominated primarily by introduced species. This portion of the project site appears to have been disturbed for a long period of time. Old Hawaiian terraces can be found in the area. More recent signs of man include trails, old house sites, large clumps of old mango trees (*Mangifera indica*), and a few ornamental plants such as gardenia (*Gardenia augusta*), red hibiscus (*Hibiscus rosa-sinensis*), and croton (*Codiaeum variegatum*). Old cattle pastures and fencelines are also occasionally encountered. During the time between 1840 and 1856, coffee was planted in the valleys of the north shore (Hume 1986). A few coffee plants (*Coffea arabica*) can still be found in the mixed introduced forests. In 1967, a large fire destroyed much of the vegetation on the slopes behind Hanalei (Hume 1986).

This vegetation type is composed of a mosaic of stands of different species. Near the proposed powerplant site, a very large forest of bamboo (*Bambusa vulgaris*), 30 to 35 ft. high, covers much of the slopes. Very little light is able to penetrate the dense growth, and it is perpetually twilight in these forests. Only a few shade-tolerant species such as *Blechnum occidentale*, wood fern (*Christella parasitica*), basketgrass (*Oplismenus hirtellus*), and *Athyriopsis japonica* are found in the bamboo forest. The ground is usually covered with leaf litter from the forest above. A few, large, old trees of mango and roseapple (*Syzygium jambos*) are found scattered throughout this forest.

In some places, roseapple trees (40 to 45 ft. high) form dense groves along the trail and the river banks. A luxuriant carpet of roseapple seedlings is often the dominant ground cover in these forests.

Along the trail and on the hillsides are forestry plantings of Eucalyptus robusta, ironwood (Casuarina equisetifolia), false wiliwili (Adenanthera pavonina), and paperbark (Melaleuca quinquenerva). Of these trees, paperbark forms the largest stands and covers an extensive portion of the hillsides. It is somewhat fire resistant and rapidly colonizes burned-over areas (Smith 1985). The plants have aggressively spread over a greater area since the fire of 1967 (R. Daehler, pers. comm.). Strawberry guava (Psidium cattleianum) and downy myrtle (Rhodomyrtus tomentosa), as well as uluhe (Dicranopteris linearis), form a dense tangle between the paperbark trees.

Java plum (Syzygium cumini) occurs as small stands or scattered trees along the river.

Scattered hau forests (Hibiscus tiliaceus) are also found along the river; these are discussed in greater detail in a later section.

Where the different stands of trees meet, there is an overlap of species.

A number of trails criss-cross the area and meander off the larger, main pig hunter's trail. The trails are generally more open and support a rather dense growth of assorted grasses, sedge, and weedy, herbaceous species. In some places, puddles of standing water support a number of wetland plants.

3. Hau Forest

Hau (Hibiscus tiliaceus) is generally thought to be native to the Hawaiian Islands, although there is still some disagreement as to its origin. Some believe that it is an early aboriginal introduction. The bark, stripped from the branches, was used for making a very strong cordage and rope.

The hau is a small tree, 18 to 20 ft. high, which produces numerous, long, spreading branches which may root where the branches touch the moist ground. The plants commonly form a dense, almost impenetrable tangle of intertwining branches and trunks. Ground cover usually consists of scattered clumps of shade-tolerant species.

On the project site, scattered patches of hau forests are found all along the river and sometimes extend from the river up to the valley slopes, especially in the areas where a tributary stream crosses the hau forest. One of the largest hau forests can be found above the intake site, outside the project area, near Waipunaea Falls.

Generally, the hau forests in the lower half of the project site (below Pekoa Falls) support a ground cover of basketgrass (Oplismenus hirtellus), downy wood fern (Christella dentata), and sword fern (Nephrolepis multiflora). Yellow ginger (Hedychium flavescens) may occasionally be encountered. Two species of aboriginal introduction, the bitter yam or pi'oi (Dioscorea bulbifera) and pi'ia (Dioscorea pentaphylla), are found here. Large mango trees, some 70 to 80 ft. tall and with a trunk diameter of 5 ft., may also be observed here.

Above Pekoa Falls, the hau forests generally support a ground cover of mixed ferns, usually palapalai (Microlepia strigosa) and sword fern (Nephrolepis multiflora). Basketgrass and yellow ginger are rarely observed. Very scattered trees of 'ohi'a (Metrosideros collina ssp. polymorpha), 12 to 15 ft. high, are also found in these forests. Among the moss and liverwort clumps on the branches and trunks of the hau, the epiphytic pakahakaha fern (Pleopeltis thunbergiana) is frequently seen.

4. Guava Forest

Guava (Psidium guajava), which was probably introduced to the islands by Don Marin before 1825 (Degener and Degener 1932 et seq.), is found in moist to wet areas from low to middle elevations throughout the islands. Guava forests form one of the most common vegetation types in the islands (Fosberg 1972). It is spread by wild pigs, cattle, and fruit-eating (frugivorous) birds. It is also able to reproduce and spread rapidly from root sprouts. Guava is able to form dense, solid stands in moist to wet areas which have been disturbed.

On the project site, this vegetation type is found on the valley floor bordering the river and along the tributary streams. Individuals of the species range from 15 to 30 ft. in height and may have trunks 4 to 6 in. in diameter. The guava often forms a closed canopy forest, i.e., crowns of foliage touching and over-lapping. In the closed forest, ground cover consists of a mixture of ferns -- hairy sword fern (Nephrolepis multiflora), downy wood fern (Christella dentata), wood fern (Christella parasitica), neke (Cyclosorus interruptus), palapalai (Microlepia strigosa), ho'i'o (Diplazium sandwichianum), and Blechnum occidentale -- and grasses -- Hilo grass (Paspalum conjugatum), hairy crabgrass (Digitaria ciliaris), and basketgrass (Oplismenus hirtellus). In some places, shampoo ginger or 'awapuhi kua hiwi (Zingiber zerumbet) may be locally common.

In places where the guava canopy is open, Job's tears (Coix lachryma-jobi), Californiagrass (Brachiaria mutica) or uluhe (Dicranopteris linearis) may be the most abundant ground cover. Job's tears may be very dense in low-lying, wet areas.

Trees of 'ohi'a (Metrosideros collina ssp. polymorpha), up to 30 ft. high, are found scattered throughout this vegetation type. The number of 'ohi'a trees increases in the transition zone between the guava forest and the mixed native-introduced forest. Also occasionally observed are trees of kukui (Aleurites moluccana), especially in the bottom of draws of gullies. Locally common are patches of yellow ginger (Hedychium flavescens) and wait-a-bit (Caesalpinia sepiaria). Dense patches of lantana (Lantana camara), with some plants up to 12 ft. tall, are also locally common.

Plants cultivated by the early Hawaiians are frequently observed in this vegetation type. These include banana or mai'a (Musa sp.), ohe (Schizostachyum glaucifolium), mountain apple or 'ohi'a-ai (Syzygium malaccense), 'awa (Piper methysticum), and ti (Cordyline terminalis).

5. Mixed Native-Introduced Forest

The valley narrows above Pekoa Falls and in some places the steep valley walls come down to the river's edge. Here the vegetation appears to be somewhat less disturbed. The composition of the vegetation changes gradually as one proceeds from the falls to the intake site. The kinds and numbers of native species increases. 'Ohi'a or 'ohi'a-lehua (Metrosideros collina ssp. polymorpha) becomes the most abundant tree species. The trees may be 30 to as much as 50 ft. high in some places. 'Ohi'a is found in moderately moist to wet situations at fairly low to middle elevations on the six larger Hawaiian Islands (Fosberg 1972). On the older, more weathered islands, such as Kaua'i, 'ohi'a typically forms a mixed native forest with other tree and shrub species. On the project site, the other native tree and shrub species include papala-kepau (Pisonia umbellifera), kopiko (Psychotria kaduana), hame (Antidesma platyphyllum), kawa'u (Ilex anomala), 'ohi'a-ha (Syzygium sandwicensis), manono (Gouldia terminalis), mamaki (Pipturus helleri), and olomea (Perrottetia sandwicensis).

Guava (Psidium guajava) and strawberry guava (Psidium cattleianum), both introduced species, often form a secondary tree or subcanopy layer. Dense thickets of lantana (Lantana camara), some as high as 10 or 12 ft., form a prickly shrub layer in many places, especially where the tree canopy is open and the slopes are not too steep.

A number of epiphytic ferns and a few climbers, such as 'ie'ie (Freycinetia arborea) and maile (Alyxia olivaeformis), are found in this vegetation type. Among the epiphytic ferns are three species of 'ekaha fern (Elaphoglossum alatum, Elaphoglossum crassifolium, Elaphoglossum hirtum), wahine-noho-mauna (Adenophorus tamariscinus), Adenophorus pinnatifidus, kolokolo (Grammitis tenella), and bird's-nest fern or 'ekaha (Asplenium nidus).

6. Grass-Fern Association

Scattered along the valley floor in places where the terrain is relatively level or terraced are medium to large, open clearings vegetated by grasses and ferns. The neke fern (*Cyclosorus interruptus*) is abundant in these areas where it forms immense stands. It reproduces primarily by its extensively creeping rhizomes. Its fronds stand stiffly erect among several grass, sedge and weedy, herbaceous species such as Job's tears (*Coix lachryma-jobi*), Californiagrass (*Brachiaria mutica*), large crabgrass (*Digitaria ciliaris*), Hilo grass (*Paspalum conjugatum*), Glenwoodgrass (*Sacciolepis indica*), *Pycreus polystachyos*, kyllinga (*Kyllinga brevifolia*), primrose willow or kamole (*Ludwigia octivalvis*), and honohono (*Commelina diffusa*).

Other fern species which may occur here include downy wood fern (*Christella dentata*), ho'i'o (*Diplazium sandwichianum*), and hairy sword fern (*Nephrolepis multiflora*).

Around the margins of this vegetation type, clumps of ti plants (*Cordyline terminalis*) and dense stands of lantana (*Lantana camara*) are frequently found. The white-flowered koali-pehu vine (*Ipomoea alba*) may be observed here.

These areas which support the grass-fern association were probably used for taro cultivation by the Hawaiians and, perhaps, by later immigrants. Throughout much of Polynesia and Micronesia, the neke fern is characteristically found associated with cultivated wetlands. When extensive patches of this fern are found in the absence of cultivated species, it is usually indicative of prior cultivation (Stemmermann 1981).

7. Uluhe with Scattered Trees

Uluhe or false staghorn fern (*Dicranopteris linearis*) forms a dense tangle of long, creeping, wiry stems with upright fronds. On the steep slopes which have been scarred by landslides, uluhe is one of the first pioneers to revegetate the slopes. Uluhe has also now formed dense thickets on the lower valley slopes which were burned during the fire of 1967.

The steep slopes from the homestead lands to Pu'u o Miki support a dense growth of uluhe fern with scattered clumps and individuals of paperbark trees (*Melaleuca quinquenerva*). Other tree and shrub species in this area include hala (*Pandanus odoratissimus*), roseapple (*Syzygium jambos*), guava (*Psidium guajava*), strawberry guava (*Psidium cattleianum*), 'ohi'a (*Metrosideros cóllina* ssp. *polymorpha*), and koa (*Acacia koa*). Kukui trees (*Aleurites moluccana*) are abundant in gullies.

The number of introduced trees species begins to diminish as one proceeds up the valley and the native 'ohi'a becomes the most abundant tree in the uluhe tangle on the slopes.

Where the fern mat is thin, plants such as broomsedge (*Andropogon virginicus*), 'uki (*Machaerina angustifolia*), wawae-'iole (*Lycopodium cernuum*), pala'a (*Sphénomeris chinensis*), hairy sword fern (*Nephrolepis multiflora*), and Glenwood-grass (*Sacciolepis indica*) may be found.

THREATENED OR ENDANGERED SPECIES

No officially listed, proposed, or candidate Threatened or Endangered plant species (U. S. Fish and Wildlife Service 1980) were found during the course of this survey.

The status of the two mamaki species (Pipturis helleri, Pipturis kauaiensis) found during this survey is considered "uncertain," i.e., insufficient information available to determine if endangered, by Fosberg and Herbst (1975). However, both species occur in the native forests on the Wai'ale'ale plateau and in the many deeply dissected valleys. Recently collected specimens can be found in herbarium collections. On the project site, the plants generally occur as scattered individuals. The plants are more numerous along the river above the project site.

DISCUSSION AND RECOMMENDATIONS

A total of 161 vascular plant species were inventoried during this survey. Of these, 88 (55%) are introduced or exotic species; 60 (37%) are native; and 13 (8%) are of Polynesian introduction. Among the 60 native species, 27 are indigenous (i.e., occur in the Hawaiian Islands and elsewhere) and 33 are endemic (i.e., occur only in the Hawaiian Islands). The majority, some 75%, of the Pteridophytes (Ferns and Fern Allies) are native. Introduced species are the most abundant elements among the Flowering Plants (Monocotyledons and Dicotyledons).

The vegetation around the proposed powerhouse and the lower half of the project site is dominated by forests of introduced species. In the upper half of the project site, from Pekoa Falls to the intake site, 'ohi'a trees (Metrosideros collina ssp. polymorpha) and other native species become more common.

Past disturbances by human beings and grazing animals, as well as feral pigs, can be observed throughout the project site. On the lower half of the project area, old house sites, abandoned livestock fencing and pastures, and forestry plantings are frequently found. Areas scarred by fire may also be seen on the slopes above the homestead lands. Traces of former occupation or use by the early Hawaiians are evident throughout the entire project site. Plants cultivated by the Hawaiians such as taro (Colocasia esculenta), 'awa (Piper methysticum), mountain apple (Syzygium malaccense), ohe (Schizostachyum glaucifolium) and banana (Musa sp.) are not uncommon. Large flat areas along the river, now vegetated by a grass-fern association, were probably used by the Hawaiians to grow taro.

The proposed project is not expected to have a major impact on the native vegetation. The proposed penstock route, diversion weirs, access road, powerhouse, and transmission line will impact largely vegetation dominated by introduced species. The native species found on the project site are found in similar environmental habitats throughout the wet valleys of the north coast area as well as the forests of the Wai'ale'ale plateau. None of these species is considered Threatened or Endnagered by the Federal and State governments.

Removal of vegetation, however, will result in increased soil erosion and sedimentation. It is recommended that disturbance from construction be kept to a minimum whenever possible. All cuts and exposed areas, especially on slopes, should be revegetated as soon as possible. Plant species already on the project site, such as Hilo grass (*Paspalum conjugatum*), narrow-leaved carpetgrass (*Axonopus affinis*), palapalai (*Microlepia strigosa*), hairy sword fern (*Nephrolepis multiflora*), and Spanish clover (*Desmodium canum*) should be used.

Streamside vegetation should be monitored on the project site. Withdrawal of water from the river and tributary streams will reduce instream flow. Woody growth may invade the present streamside vegetation now composed principally of grass and herbaceous species. During periods of heavy rain, this narrower river channel may flood. The woody vegetation occurring along the river's former edge may also contribute debris to the flood waters. Appropriate measures to remove and control brush along parts of the river may then have to be implemented.

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APPENDIX I. PLANT SPECIES LIST, HANALEI, ISLAND OF KAUA'I

In the plant species list, families are arranged alphabetically within each of three groups: Pteridophytes, Monocotyledons, and Dicotyledons. Taxonomy and nomenclature of the Pteridophytes (Ferns and Fern Allies) follow C. H. Lamoureux's unpublished checklist (1984); taxonomy and nomenclature of the flowering plants (Monocotyledons and Dicotyledons) follow St. John (1973) except where more recently accepted names are used. Hawaiian names used are in accordance with Porter (1972) or St. John (1973). The following information is given:

1. Botanical name with author citation.
2. Common English or Hawaiian name, when known.
3. Biogeographic status of the species. The following symbols are used:

   E = endemic = native only to the Hawaiian Islands

   I = indigenous = native to the Hawaiian Islands and also to one or more other geographic areas

   P = Polynesian = plants of Polynesian introduction; all those plants brought by the Polynesian immigrants prior to contact with the Western world

   X = introduced or exotic = not native to the Hawaiian Islands; brought here intentionally or accidentally after Western contact.

4. Vegetation types. Seven vegetation types are recognized on the project area and are discussed in detail in the text. The number heading each of the columns refers to the following vegetation types:

   1 = Streamside vegetation

   2 = Mixed introduced forests

   3 = Hau forest

   4 = Guava forest

   5 = Mixed native-introduced forest

   6 = Grass-fern association

   7 = Uluhe with scattered trees

5. Within each of the vegetation types, the relative abundance of each species or its absence (-) is given. These ratings reflect the abundance of the particular species within the project area and are not applicable to areas outside the project. The following symbols are used:

A = abundant = the major or dominant species in a given vegetation type

C = common = distributed throughout a given vegetation type in large numbers

L = locally common = found in localized patches where it occurs in relatively large numbers but otherwise occasional to rare within a given vegetation type

O = occasional = distributed throughout a given vegetation type in moderate numbers

U = uncommon = observed infrequently but not more than 10 times in a given vegetation type

R = rare = observed 1 to 10 times in a given vegetation type

Scientific name	Common name	Status	1	2	3	4	5	6	7
			Vegetation types						
PTERIDOPHYTA (Ferns and Fern Allies)									
ADIANTACEAE (Maiden-hair Fern Family)									
Adiantum capillus-veneris L.	'iwa'iwa	I	-	R	-	-	R	-	-
ASPLENIACEAE (Bird's-nest Fern Family)									
Asplenium nidus L.	bird's-nest fern, 'ekaha	I	-	-	-	-	R	-	-
ATHYRIACEAE (Athyrium Fern Family)									
Athyriopsis japonica (Thunb.) Ching		X	U	O	O	U	U	U	-
Diplazium sandwichianum (Presl) Diels	ho'i'o	E	U	-	-	O	C	U	-
BLECHNACEAE (Blechnum Family)									
Blechnum occidentale L.	blechnum	X	L	O	O	L	U	-	-
Sadleria cyatheoides Kaulf.	'ama'u	E	-	-	-	U	U	-	-
DENNSTAEDTIACEAE (Lace-fern Family)									
Microlepia strigosa (Thunb.) Presl	palapalai, palai	I	U	U	O	O	O	-	-
DICKSONIACEAE (Tree-fern Family)									
Cibotium st.-johnii Krajina	amahu, hapu'u	E	-	-	-	U	U	-	O
ELAPHOGLOSSACEAE (Elaphoglossum Family)									
Elaphoglossum alatum Gaud.	'ekaha	E	-	-	-	-	U	-	-
Elaphoglossum crassifolium (Gaud.) Anders. & Crosby	'ekaha-ula, hoe-a- Maui	E	-	-	-	U	O	-	-
Elaphoglossum hirtum var. micans (Mett.) C. Chr.		E	-	-	-	-	U	-	-
GLEICHENIACEAE (False stag-horn Fern Family)									
Dicranopteris linearis (Burm.) Underw.	uluhe	I	-	L	-	L	L	-	A
GRAMMITACEAE (Finger Fern Family)									
Adenophorus hymenophylloides (Kaulf.) H. & G.	pai, palai-huna	E	-	-	-	-	R	-	-
Adenophorus pinnatifidus Gaud.		E	-	-	-	-	U	-	-

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
Adenophorus tamariscinus (Kaulf.) H. & Grev.	wahine-noho-mauna	E	-	-	-	-	O	-	-
Grammitis tenella Kaulf.	kolokolo, mahina-lau	E	-	-	-	R	U	-	-
HEMIONITIDACEAE (Gold Fern Family)									
Pityrogramma calomelanos (L.) Link	gold fern, silver fern	X	-	R	-	-	U	-	U
HYMENOPHYLLACEAE (Filmy Fern Family)									
Gonocormus minutus (Blume) v. d. Bosch	gonocormus	I	-	-	-	R	-	-	-
Mecodium recurvum (Gaud.) Copel.	'ōhi'a-ku	E	-	-	-	-	R	-	-
LINDSAEACEAE (Lindsaea Family)									
Sphenomeris chinensis (L.) Maxon	pala'a, palapala'a	I	-	O	-	U	U	-	U
LYCOPODIACEAE (Club Moss Family)									
Lycopodium cernuum L.	wawae-'iole	I	-	R	-	-	-	-	U
Lycopodium phyllanthum H. & A.	wawae-'iole	E	-	R	-	R	-	-	-
NEPHROLEPIDACEAE (Sword Fern Family)									
Nephrolepis biserrata (Sw.) Schott cv. "Furcans"	fishtail fern	X	-	U	-	-	-	-	-
Nephrolepis cordifolia (L.) Presl	ni'ani'au, kupukupu	I	-	-	-	-	U	-	-
Nephrolepis exaltata (L.) Schott	ni'ani'au, kupukupu	I	-	-	-	-	U	-	-
Nephrolepis multiflora (Roxb.) Jarrett ex Morton	hairy sword fern	X	L	C	O	C	C	A	O
Nephrolepis sp.		X	-	R	-	-	-	-	-
OPHIOGLOSSACEAE (Adder's-tongue Fern Family)									
Ophioglossum pendulum ssp. falcatum (Presl) Clausen	puapua-moe	E	-	-	-	R	-	-	-
POLYPODIACEAE (Polypody Fern Family)									
Microsorium spectrum (Kaulf.) Copel.	pe'ahi	E	-	-	-	-	R	-	-
Phlebodium aureum (L.) J. Sm.	laua'e-haole	X	-	R	R	-	R	-	-
Phymatosorus scolopendria (Burm.) Pic.-Serm.	laua'e, lauwa'e	X	-	R	-	R	-	-	-
Pleopeltis thunbergiana Kaulf.	pakahakaha, 'ekaha-'akolea	I	-	U	O	O	O	-	-

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
PSILOTACEAE (Psilotum Family)									
Psilotum nudum (L.) Beauv.	moa, pipi	I	-	U	U	U	-	-	-
SELAGINELLACEAE (Selaginella Family)									
Selaginella arbuscula (Kaulf.) Spring	lepelepe-a-moa	E	-	-	-	R	O	-	-
THELYPTERIDACEAE (Downy Wood Fern Family)									
Christella cyatheoides (Kaulf.) Holtt	kikawaio	E	-	-	-	-	U	-	-
Christella dentata (Forsk.) Brownsey & Jermy	downy wood fern	X	O	C	O	C	O	O	-
Christella parasitica (L.) Level.	wood fern, oakfern	X	-	O	O	C	U	-	-
Cyclosorus interruptus (Willd.) H. Ito	neke	I	L	R	-	L	O	A	-
Pneumatopteris sandwicensis (Brack.) Holtt.		E	-	-	-	O	O	-	-
VITTARIACEAE (Tape Fern Family)									
Vittaria elongata Sw.	oheohe	I	-	U	R	R	-	-	-
MONOCOTYLEDONS (Flowering Plants)									
ARACEAE (Arum Family)									
Alocasia macrorrhiza (L.) Sweet	'ape, apii	P	R	R	-	-	-	-	-
Colocasia esculenta var. antiquorum (Schott.) Hubb. & Rehd.	taro, kalo	P	O	-	-	-	-	-	-
Scindapsus aureus (Lind. ex Andre) Engl.	taro vine, pothos	X	-	R	-	-	-	-	-
BUTOMACEAE (Butomus Family)									
Hydrocleys nymphoides (Humb. & Bonpl. ex Willd.) Buch.	water poppy	X	-	R	-	-	-	-	-
COMMELINACEAE (Spiderwort Family)									
Commelina diffusa Burm. f.	honohono	X	C	O	U	O	-	C	-
CYPERACEAE (Sedge Family)									
Cyperus laevigatus L.	makaloa, 'ehu'awa	I	-	R	-	-	-	-	-

Scientific name	Common name	Status	Vegetation type 1	2	3	4	5	6	7
Eleocharis radicans (Poir.) Kunth		X	O	R	-	-	-	R	-
Fimbristylis dichotoma (L.) Vahl	tall fringe rush	I	U	R	R	-	-	-	U
Kyllinga brevifolia Rottb.	kyllinga, kili-o-opu	X	O	U	-	-	-	O	-
Machaerina angustifolia (Gaud.) Koyama	'uki	I	-	R	-	-	R	-	U
Mariscus cyperinus (Retz.) Vahl		I	U	R	-	-	-	U	-
Pycreus polystachyos (Rottb.) Beauv.		I	O	O	-	U	U	O	U
Scirpus validus Vahl	bulrush, 'aka'akai	I	R	-	-	-	-	-	-
DIOSCOREACEAE (Yam Family)									
Dioscorea bulbifera L.	bitter yam, pi'oi	P	-	U	R	R	-	-	-
Dioscorea pentaphylla L.	pi'ia	P	-	O	O	-	-	-	-
GRAMINEAE (Grass Family)									
Andropogon virginicus L.	broomsedge	X	-	U	-	-	-	-	O
Axonopus affinis Chase	narrow-leaved carpetgrass	X	-	U	-	-	-	-	-
Bambusa aff. vulgaris Schrad. ex Wendl.	bamboo	X	-	A	-	-	-	-	-
Brachiaria mutica (Forsk.) Stapf	paragrass, Californiagrass	X	A	L	R	O	-	C	-
Coix lachryma-jobi L.	Job's tears, 'ohe pu'ohe'ohe	X	A	U	-	O	U	A	-
Digitaria ciliaris (Retz.) Koeler	large crabgrass	X	L	U	-	C	O	C	-
Digitaria radicosa (Presl) Miq.	crabgrass	X	-	R	-	-	-	-	-
Digitaria setigera Roth ex R. & S.	itchy crabgrass, kukai pua'a	X	R	R	-	-	-	-	-
Oplismenus hirtellus (L.) Beauv.	basketgrass, honohono-kukui	X	O	O	O	O	O	R	-
Paspalum conjugatum Berg.	Hilo grass, mau'u-Hilo	X	C	O	O	C	O	C	U
Paspalum orbiculare Forst. f.	ricegrass, mau'u-laiki	X	-	U	-	-	-	-	-
Paspalum urvillei Steud.	Vaseygrass	X	U	U	-	-	R	-	-
Sacciolepis indica (L.) Chase	Glenwood grass	X	O	O	O	O	O	C	O
Schizostachyum glaucifolium (Rupr.) Munro	ohe	P	-	-	-	R	-	-	-
Setaria geniculata (Poir.) Beauv.	perennial foxtail	X	O	-	-	R	R	-	U
Sporobolus indicus (L.) R. Br.	West Indian dropseed	X	-	U	-	-	-	-	-
LILIACEAE (Lily Family)									
Cordyline terminalis (L.) Kunth	ti, ki	P	-	U	-	U	U	O	O

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
MUSACEAE (Banana Family)									
Musa sp.	banana, mai'a	P	-	-	-	L	-	-	-
ORCHIDACEAE (Orchid Family)									
Phaius tankervilliae (Banks ex L'Her.)	phaius	X	-	-	-	-	R	-	-
Spathoglottis plicata Bl.	Chinese ground orchid	X	-	R	-	-	R	U	U
PALMAE (Palm Family)									
Cocos nucifera L.	coconut, niu	P	-	R	-	-	-	-	-
PANDANACEAE (Screw Pine Family)									
Freycinetia arborea Gaud.	ie'ie	E	-	-	-	O	O	R	O
Pandanus odoratissimus L.	pandanus, hala, puhala	I	-	R	-	-	-	-	O
ZINGIBERACEAE (Ginger Family)									
Hedychium coronarium Koenig	white ginger, 'awapuhi ke'oke'o	X	R	U	U	U	-	-	-
Hedychium flavescens Carey	yellow ginger, 'awapuhi melemele	X	U	O	O	O	-	-	-
Zingiber zerumbet (L.) Roscoe	shampoo ginger, 'awapuhi kua hiwi	P	-	O	-	L	O	U	-
DICOTYLEDONS (Flowering Plants)									
ANACARDIACEAE (Mango Family)									
Mangifera indica L.	mango, manako	X	-	O	U	-	-	-	R
APOCYNACEAE (Periwinkle Family)									
Alyxia olivaeformis Gaud.	maile	E	-	-	-	-	U	-	-
AQUIFOLIACEAE (Holly Family)									
Ilex anomala H. & A.	kawa'u, ka'awa'u	E	-	-	-	-	R	-	-
CARYOPHYLLACEAE (Carnation Family)									
Drymaria cordata (L.) Willd. ex R. & S.	drymaria, pipili	X	O	U	-	O	O	-	-

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
CASUARINACEAE (Casuarina Family)									
Casuarina equisetifolia Stickm.	ironwood	X	-	R	-	-	-	-	-
Casuarina littoralis Salisb.		X	-	R	-	-	-	-	-
CELASTRACEAE (Bittersweet Family)									
Perrottetia sandwicensis Gray	olomea, pua'a olomea	E	-	-	-	-	U	-	U
COMPOSITAE (Daisy Family)									
Adenostemma lavenia (L.) Ktze.	kamanamana	I	U	-	-	R	-	-	-
Ageratum houstonianum Mill.		X	O	U	U	U	U	O	U
Crassocephalum crepidioides (Benth.) S. Moore	crassocephalum	X	U	U	-	-	-	-	-
Elaphantopus mollis HBK.	elephant's foot	X	O	U	R	O	U	U	-
Erechtites valerianaefolia (Wolf) DC.	purple fireweed	X	O	O	-	R	R	U	-
Erigeron bonariensis L.	hairy horseweed, ilioha	X	-	R	-	-	R	U	-
Pluchea odorata (L.) Cass.	pluchea, shrubby fleabane	X	-	U	-	-	R	R	-
CONVOLVULACEAE (Morning-glory Family)									
Ipomoea alba L.	moonflower, koali-pehu	X	-	-	-	U	U	O	-
Ipomoea indica (Burm.) Merr.	koali-'awania	I	-	-	-	R	-	-	-
CRUCIFERAE (Mustard Family)									
Nasturtium microphyllum Boenn. ex Reichenb.	watercress, leko	X	R	-	-	-	-	-	-
Nasturtium sarmentosum (DC.) Schinz & Guillaumin	pa'ihi	P	R	-	-	-	-	-	-
EUPHORBIACEAE (Spurge Family)									
Aleurites moluccana (L.) Willd.	kukui, tutui	P	R	R	R	O	U	-	L
Antidesma platyphyllum Mann	hame, mehame	E	-	-	-	-	U	-	U
Codiaeum variegatum (L.) Bl.	croton	X	-	R	-	-	-	-	-
LEGUMINOSAE (Pea Family)									
Acacia koa Gray	koa	E	-	-	-	-	-	-	O
Adenanthera pavonina L.	false wiliwili, red sandalwood	X	-	R	-	-	-	-	R
Albizia aff. falcataria (L.) Fosb.	albizia	X	-	-	-	-	-	-	R

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
Caesalpinia sepiaria Roxb.	wait-a-bit, Mysore thorn	X	-	O	R	L	-	-	-
Cassia lechenaultiana DC.	partridge pea, lauki	X	-	R	-	-	-	-	-
Desmodium canum (Gmel.) Schinz & Thell.	Spanish clover, ka'imi	X	U	O	-	O	-	-	U
Desmodium triflorum (L.) DC.	three-flowered beggarweed	X	-	R	-	-	-	-	-
Desmodium uncinatum (Jacq.) DC.	Spanish clover, chili clover	X	-	U	-	-	-	-	-
Mimosa pudica var. unijuga (Duchass. & Walp.) Griseb.	sensitive plant, pua-hilahila	X	U	U	-	O	-	-	-
Stylosanthes guianensis (Aubl.) Sw.	pencil flower	X	-	R	-	-	-	-	-
LOBELIACEAE (Lobelia Family)									
Laurentia longiflora (L.) Engl.	Star-of-Bethlehem, istoma, hippobroma	X	R	R	-	R	-	-	-
LYTHRACEAE (Loosestrife Family)									
Cuphea carthagenensis (Jacq.) Macbride	Colombian cuphea, puakamoli	X	O	U	U	U	U	O	-
MALVACEAE (Hibiscus Family)									
Hibiscus rosa-sinensis L.	red hibiscus	X	-	R	-	-	-	-	-
Hibiscus tiliaceus L.	hau	I	L	C	A	U	-	-	U
Sida rhombifolia L.	Cuba jute	X	-	R	-	-	-	-	-
MELASTOMATACEAE (Melastoma Family)									
Melastoma malabathricum L.	Malabar melastome	X	-	L	-	-	R	-	R
MORACEAE (Mulberry Family)									
Cannabis sativa L.	pot, grass, pakalolo	X	-	R	-	-	-	-	-
Cecropia peltata Sandmark	trumpet tree, guarumo	X	-	-	-	-	-	-	R
MYRSINACEAE (Myrsine Family)									
Ardisia humilis Vahl	shoebutton ardisia	X	-	R	-	-	-	-	-
MYRTACEAE (Myrtle Family)									
Eucalyptus robusta Sm.	swamp mahogany	X	-	U	-	-	-	-	-
Melaleuca quinquenerva (Cav.) Blake	paper bark, cajeput tree	X	-	L	-	-	-	-	L
Metrosideros collina ssp. polymorpha (Gaud.) Rock	'ohi'a-lehua, 'ohi'a	E	O	U	U	O	A	O	C

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
Psidium cattleianum Sabine var. cattleianum	strawberry guava, waiawi	X	-	C	U	-	O	U	O
Psidium cattleianum f. lucidum Degener	yellow strawberry guava, waiawi	X	-	-	-	-	R	-	-
Psidium guajava L.	guava, kuawa	X	O	O	O	A	C	-	O
Rhodomyrtus tomentosa (Ait.) Hassk.	downy myrtle, rose myrtle	X	-	L	-	-	-	-	U
Syzygium cumini (L.) Skeels	Java plum, palama	X	O	A	R	U	-	-	-
Syzygium jambos L.	rose apple, 'ohi'a-loke	X	-	A	U	U	-	-	O
Syzygium malaccense (L.) Merr. & Perry	mountain apple, 'ohi'a-ai	P	-	U	-	L	-	-	-
Syzygium sandwicensis Gray	'ohi'a-ha	E	-	-	-	-	R	-	U
NYCTAGINACEAE (Four O'clock Family)									
Pisonia umbellifera (J. R. & G. Forst.) Seem.	papala-kepau	E	-	-	-	U	O	-	-
OLEACEAE (Olive Family)									
Noronhia emarginata (Lam.) Stadm.	Madagascar olive	X	-	R	-	-	-	-	-
ONAGRACEAE (Evening Primrose Family)									
Ludwigia octivalvis (Jacq.) Raven	primrose willow, kamole	I	O	U	R	-	-	O	-
OXALIDACEAE (Wood Sorrel Family)									
Oxalis corniculata L.	yellow wood sorrel, 'ihi	I	R	-	-	-	-	-	-
PIPERACEAE (Pepper Family)									
Peperomia tetraphylla (Forst f.) H. & A.	'ala'ala-wai-nui	I	-	-	-	R	R	-	-
Peperomia sp.	'ala'ala-wai-nui	E	-	-	R	-	R	-	-
Piper methysticum Forst.	'awa, kava	P	-	-	-	R	-	-	-
POLYGONACEAE (Buckwheat Family)									
Polygonum capitatum Ham. ex Don	polygonum	X	O	-	-	-	-	-	-
Polygonum glabrum Willd.	knotweed, kamole	X	U	-	-	-	-	-	-
RANUNCULACEAE (Buttercup Family)									
Ranunculus aff. repens L.	creeping buttercup	X	-	R	-	-	-	-	-

Scientific name	Common name	Status	Vegetation types 1	2	3	4	5	6	7
ROSACEAE (Rose Family)									
Rubus rosaefolius Sm.	thimbleberry	X	O	U	-	O	O	O	U
RUBIACEAE (Coffee Family)									
Coffea arabica L.	Arabian coffee	X	-	R	-	-	-	-	-
Gardenia augusta (L.) Merr.	gardenia, kiele	X	-	R	-	-	-	-	-
Gouldia terminalis (H. & A.) Hbd.	manono	E	-	-	-	-	O	R	-
Psychotria kaduana (C. & S.) Fosb.	kopiko	E	-	U	-	U	O	-	-
RUTACEAE (Rue Family)									
Citrus aurantifolia (Christm.) Swingle	lime	X	-	-	-	R	-	-	-
Citrus limonia Osbeck	lemon	X	-	R	-	-	-	-	-
Citrus sinensis (L.) Osbeck	orange	X	-	-	-	R	-	-	-
THYMELAEACEAE (Akia Family)									
Wikstroemia sp.	akia	E	-	R	-	-	-	-	-
UMBELLIFERAE (Carrot Family)									
Centella asiatica (L.) Urban	Asiatic pennywort, pohekula	X	O	U	-	O	-	U	-
Cryptotaenia canadensis (L.) DC.	honeywort	X	O	-	R	-	-	-	-
Hydrocotyle verticillata Thunb.	whorled marsh pennywort	X	U	-	-	-	-	U	-
URTICACEAE (Nettle Family)									
Boehmeria grandis (H. & A.) Heller	akoka	E	-	-	-	-	U	-	-
Pilea peploides (Gaud.) H. & A.		I	R	-	-	-	-	-	-
Pipturus helleri Skottsb.	mamaki	E	-	-	-	U	O	R	-
Pipturus kauaiensis Heller	mamaki	E	U	-	-	-	U	-	-
VERBENACEAE (Verbena Family)									
Lantana camara L.	lantana, lakana	X	U	L	U	L	C	O	-
Stachytarpheta australis Mold.	Cayenne vervain	X	O	-	-	U	-	-	-
Stachytarpheta urticaefolia (Salisb.) Sims	nettle-leaved vervain	X	O	U	U	U	-	-	-

APPENDIX III

TETRAPOD VERTEBRATES OF THE LOWER HANALEI RIVER BY ANDREW J. BERGER, 1986

TETRAPOD VERTEBRATES
of the
LOWER HANALEI RIVER

by

Andrew J. Berger

Prepared for: ISLAND POWER CO., INC.
1986

Tetrapod Vertebrates of the Lower Hanalei River

By Andrew J. Berger

This report was prepared at the request of Mr. Clark M. Mower (verbal instructions at my home on May 1, 1986) of Bingham Engineering of Salt Lake City, Utah.

The field reconnaissance was made on March 1 and 2, 1986. According to my altimeter, the helicopter pilot dropped us off at an elevation of 1,250 feet on March 1; there was a light rain most of the day. When darkness came at 6:30 p.m., we made a fire and prepared to spend the night on a high bank of the river. We hiked down an additional eight hours on March 2 before reaching the car. The long and ardous descent was due in large part because of the necessity of crossing the river more than 40 times. By contrast, in a similar survey along the Wainiha River in 1982, only two crossings of the river were required.

In addition to a literature search, on May 1, 1986, I talked with Mr. Dan Moriarty, U.S. Fish & Wildlife Service, Kialuea Lighthouse, Kauai, and to Mr. Jim Krakowski, U.S. Fish & Wildlife Service, Honolulu, about the current status of the waterbirds at the Hanalei Bird Refuge. My report covers the amphibians and terrestrial vertebrates that are found slong the lower stretches (1,200 feet downward) of the Hanalei River as found on March 1 and 2, 1986.

Amphibians and Reptiles

There are no endemic amphibians or land reptiles in the Hawaiian Islands. All, therefore, have been introduced (either intentionally or accidentally) by man. None are endangered species and none are of significance for an environmental impact assessment.

I. Amphibians

1. American Bullfrog, *Rana catesbeiana*

Oliver and Shaw (1953) wrote that this "was probably one of the first species of amphibians to be introduced into the Hawaiian Islands and may have been one of the frogs that was imported prior to 1867." Bullfrogs are active primarily at night and many were heard calling along the river at our campsite on the night of March 1, 1986. Bullfrogs are serious predators on the small downy young of the endangered Hawaiian waterbirds. I have found the remains of young Koloa in the stomach of a bullfrog, and two small ducklings were taken from a bullfrog stomach at Waimea Falls Park in 1982.

2. Wrinkled Frog, *Rana rugosa*

This frog was introduced to Hawaii from Japan in 1896 (McKeown, 1978). It is most common in mountain streams, although Shallenberger (1977:245) found this species at the sea level Punahoolapa pond on the northshore of Oahu. The wrinkled frog was common in the river at the higher elevations. McKeown noted that the wrinkled frog and the bullfrog rarely are found together because the latter is such an aggressive feeder.

3. Giant Neotropical Toad, Bufo marinus

This toad was first introduced to the islands in 1932, "when Dr. C. E. Pemberton brought 148 adult toads from Puerto Rico. Eighty of these were liberated in a taro patch near Waipio, Oahu, and 69 were released in a swampy part of Manoa Valley" (Oliver and Shaw, 1953:77). "In a little over two years more than 100,000 descendents of the original stock were distributed through Dr. Pemberton's activities throughout the islands." Hunsaker and Breese (1967) wrote that this toad was "the commonest species of amphibian" in Hawaii. These toads are active primarily at night and I did not happen to see any during my night along the river. However, during December 1982 I found this toad at an elevation of approximately 1,000 feet along the Wainiha River, and it undoubtedly is found along the Hanalei River. This toad was introduced to the islands in the hope that it would aid in controlling insect pests of sugarcane (McKeown, 1978).

II. Reptiles

1. Blind Snake, Typhlina bramina

"This small secretive snake was apparently introduced from the Philippines in the dirt surrounding plants that were brought in for landscaping the campus of the Kamehameha Boys School in Honolulu. It was first found there in January of 1930" (Oliver and Shaw, 1953). These blind, worm-like snakes are rarely seen until they are flooded from underground burrows by heavy rains or unless one looks for them under branches and leaf litter on the ground. These small, harmless snakes are of no significance for an environmental assessment and I did not look for them. They are found on all of the main islands (McKeown, 1978).

2. Skinks and Geckos

Eight species of skinks (family Scincidae) and geckos (family Gekkonidae) are found on Kauai, although one species (azure-tailed skink, *Emoia cyanura*) is now thought to be rare there. McKeown (1978) wrote that whether this species "cannot successfully compete with the ubiquitous Metallic Skink, or whether it suffers from predation by the mongoose, or any combination of these variables, is presently unknown." It does not, of course, suffer from mongoose predation on Kauai. I saw several skinks during our hike down the river but was too much occupied with other activities and I did not attempt to catch any for positive identification as to species. All of these small reptiles are irrelevant to an environmental impact assessment, in part, because they adapt well to both urban and rural areas, and because all are introduced species.

Birds of the Lower Hanalei River System

Three general groups of birds occur in the Hawaiian Islands: 1) Endemic birds are those that are unique to Hawaii and occur naturally nowhere else in the world (Berger, 1981); 2) Indigenous or Native birds, those whose total range in the Pacific Basin includes the Hawaiian Islands, and 3) Introduced or alien birds, those brought to the islands by man. I refer to the "Lower Hanalei River System" because our observations were made from approximately 1,250 feet downward. It rained lightly much of the day on March 1, but this should not have affected singing by the endemic birds based on my past field work on Kauai (Berger, 1966, 1969a, b, 1975, 1981; Berger *et al.*, 1969).

I. Endemic Birds

A. Order Anseriformes

a. Family Anatidae, Ducks, Geese, and Swans

1. Koloa or Hawaiian Duck, *Anas wyvilliana*

This endangered species occurred on all of the main islands except Lanai and Kahoolawe into the 1940s. Man may have been the most serious predator on the Koloa because the birds could be hunted legally during the 1920s, when the bag limit was 25 ducks per day. The decline in taro farming, the cessation of commercial rice growing, and the draining of marshland for development also led to the decline in numbers of ducks, and the species was extirpated from all islands except Kauai by about 1960. The State Division of Fish & Game initiated a Koloa restoration program at Pohakuloa, Hawaii, in 1972, and captive-reared ducks have since been released on Oahu and Hawaii.

Swedberg (1967) described the range and life history of the Koloa on Kauai. Birds inhabit both lowland areas (e.g., the Hanalei taro patches and the refuge) and mountain streams. Swedberg found Koloa nests along the Hanalei River and I saw several birds there during our two-day field trip. The potential effects of the proposed Hanalei Hydroelectric Project will be discussed later in this report.

B. Order Strigiformes

b. Family Strigidae, Typical Owls

2. Pueo or Hawaiian Short-eared Owl, <u>Asio flammeus sandwichensis</u>

The Pueo is a permanent resident on all main islands. Only on the island of Oahu does the State Division of Forestry and Wildlife consider it to be an endangered species. On Kauai it has been found in relatively dry areas as well in the ohia rain forest at Kokee and the upper reaches of the Waialae stream. Although the Pueo is adaptable to different climatic conditions, I did not see any during my two days along the Hanalei River. Unlike most owls, the Pueo is a diurnal species and, therefore, is much more conspicous than is the nocturnal Barn Owl. The Pueo may soar at considerable heights above the ground or relatively low over the ground hovering before pouncing on their prey, typically mice and rats. The steep slopes along the sides of the river do not provide either habitat for foraging for food or for nesting. It is my considered opinion that the proposed project would have a minimal effect on any Pueo that might inhabit the area.

C. Order Passeriformes

c. Family Drepanididae, Hawaiian Honeycreepers

This is Hawaii's unique bird family. However, approximately 40 percent of the species are extinct and another 40 percent are classified as threatened or endangered. The vast majority of honeycreeper species occur well above 1,000 feet on Kauai: for example, at Kokee State Park and the Alakai Swamp region. They do not adapt well to exotic vegetation, and all nests of the two common species (Amakihi, Apapane) found on Kauai have been built in ohia trees (Berger, 1981). I neither heard nor saw any honeycreepers during my two days along the Hanalei River, but mention two species because I did see them below 1,000 feet along the Wainiha River during December 1982. These birds were not singing, the nesting season had not yet begun, and the birds undoubtedly were foraging for food in blooming ohia trees.

3. Amakihi, Hemignathus virens stejnegeri

The Amakihi was described scientifically in 1782, but the first nest of the Kauai race was not found until 1964 (Berger, 1981). The species is most common in the ohia forests of the Kokee and Alakai Swamp regions (Richardson and Bowles, 1964); nothing has been published to date on its occurrence in other regions of Kauai. Along the Wainiha River, I saw my first Amakihi at an elevation of approximately 880 feet and I saw and heard several others at higher elevations.

4. Apapane, Himatione sanguinea

This undoubtedly is the most abundant of the surviving species of honeycreepers. Scott *et al.* (in press) estimated a total population of more than one million birds on the Island of Hawaii and large numbers on Maui and Kauai. This species typically inhabits ohia-koa forests. During December 1982, I found the first Apapane at an elevation of 1,000 feet along the Wainiha River. The birds were giving callnotes only; there was no singing, which suggested that the breeding season had not yet begun (Berger, 1981). In any event, theproposed project should have no adverse effect on any honeycreeper because the large number of introduced plant species up to, and beyond, the 1000 foot elevation does not provide adequate habitat for the nesting activities of these birds, and the majority of Kauai honeycreepers inhabit ohia-koa forests well above 1000 feet elevation.

II. Indigenous Birds

These birds are native to the Hawaiian Islands but are not unique to them. In this category are 22 species of sea birds, the Hawaiian Black-crowned Night Heron, and a number of migratory species that spend their winter or nonbreeding season in the islands. I have been unable to find any evidence that any of the sea birds or the heron inhabit the upper reaches of the Hanalei River. I did find two of the winter residents there.

A. Order Charadriiformes

a. Family Scolopacidae, Sandpipers, Curlews, and Snipe

1. Wandering Tattler, *Heteroscelus incanus*

This shorebird nests in Alaska and northwestern British Columbia. This species is a regular winter resident in the Hawaiian Islands. The birds usually are seen along beaches and reef flats but I found several birds along the Hanalei River at elevations up to at least 900 feet; during December 1982, I found tattlers at an elevation of 1000 feet along the Wainiha River.

b. Family Charadriidae, Plovers

2. Lesser or Pacific Golden Plover, *Pluvialis dominica fulva*

This subspecies nests in Siberia and arctic America. It, too, is a very common winter resident, being found from sea level to at least 10,000 feet on Hawaii island. During their stay in Hawaii, they inhabit lawns in residential areas (and even the lawn around the State Capitol building in Honolulu), golf courses, pastures, shorelines and reef flats, and open mountain areas. I saw a dozen plovers along the Hanalei River at all elevations up to about 1200 feet.

III. Introduced or Alien Birds

A. Order Ciconiiformes

a. Family Ardeidae, Herons and Egrets

1. Cattle Egret, *Bubulcus ibis*

This egret is native to Spain, Africa, and Asia. The birds apparently colonized British Guiana from Africa about 1930. The birds have since moved northward into North America (Van Tyne and Berger, 1976). Cattle Egrets were imported from Florida and released on Kauai and other islands in 1959. Byrd, *et al*. (1980) reported that Cattle Egrets on Kauai had increased from the 25 released in 1959 to at least 6,800 by January 1980. I saw flocks up to 16 birds at nearly all levels of the Hanalei River.

B. Order Galliformes

b. Family Phasianidae, Pheasants, Quail, Francolins.

2. Ring-necked Pheasant, *Phasianus colchicus*

This pheasant has a wide distribution in temperate Asia. It is a highly variable species and many subspecies have been described by taxonomists. Several races have been introduced to Hawaii. *Phasianus colchicus torquatus*, a native of eastern China, was introduced to the Hawaiian Islands at an unknown date, but perhaps as early as 1865 (Caum, 1933). The pheasant is a popular game bird on Kauai, and 333 birds were reported shot during the hunting season that ended on January 17, 1982 (Department of Land and Natural Resources monthly report for January 1982). I did not see or hear any pheasants during my two days along the river, but I did see a hen along the Wainiha River during a field trip there. Moreover, the Hanalei River drains much of Unit C, a public hunting area on Kauai. According to the Division of Forestry and Wildlife, Unit C "includes many small ridges of improved pasture interlaced with gullies of thick vegetation." "Ring-necked pheasants, Japanese quail, lace-necked doves and barred doves may be harvested here" (State of Hawaii, Public Hunting Areas, Island of Kauai).

C. Order Columbiformes

c. Family Columbidae, Pigeons and Doves

3. Lace-necked or Spotted Dove, <u>Streptopelia chinensis</u>

This Asian dove was introduced to the islands at an early date; the exact date is unknown, but the birds are said to have been very common on Oahu by 1879 (Caum 1933). The species now is common to abundant on all main islands and, like the other doves in Hawaii, is classified as a game bird. Although this dove occurs where the rainfall exceeds 100 inches per year, the highest densities are found in drier areas where the introduced kiawe is one of the dominant plants. Schwartz and Schwartz (1949), for example, estimated densities as great as 200 birds per square mile in dry areas on Molokai.

The diet, as determined by examining crop contents of 91 birds, was found by the Schwartzes to consist of 77 percent weed seeds and about 23 percent fruits; animal matter was "almost negligible." Tape worm parasitism, however, was found to be heavy, indicating that the small amount of animal matter eaten by the doves was important in contracting the worm parasites.

The Lace-necked Dove is common in residential areas, in dry kiawe habitat, in pasture and agricultural land, and in open areas in the mountains. I saw several doves in the lower reaches of the river.

4. Barred Dove, Geopelia striata

This species is called the Zebra Dove in its native range in the Orient and in Australia. This dove is said to have been introduced to the islands after 1922 (Bryan, 1958). It has been a remarkably successful introduction and it now is abundant on all of the islands. The Barred Dove also prefers the drier areas where seeds are abundant. Schwartz and Schwartz (1949) estimated desnsities as great as 400 to 800 birds per square mile in some areas on Oahu (e.g., Barber's Point to Makaha) and on Molokai. One study of the food habits of this dove in Hawaii revealed that the diet consists of 97 percent seeds and other plant materials; the 3 percent animal matter included several species of beetles, weevils, and wireworm larvae.

Doves avoid dense forests; they are common in residential areas, cutover fields, pasture, and along jeep trails wherever there is a supply of weed seeds. It occurs in the lower regions of the valley.

D. Order Strigiformes

d. Family Tytonidae, Barn Owls

5. Barn Owl, Tyto alba pratincola

Barn Owls differ from other owls in that they have a heart-shaped facial disc of feathers, hence the name of "monkey-faced owl." Barn Owls were brought to the islands (1958 through 1963) in the hopes that they would control rats in the sugarcane fields. They did not. Food habits studies conducted thus far, however, have shown that Barn Owls in Hawaii prey largely on house mice and, especially on Kauai, on birds (Tomich, 1971; Baker and Russell, 1980; Byrd and Telfer, 1980). Moreover, the owls have spread over much of the island rather than remaining in the cane fields. Au and Swedberg (1966) summarized the status from the first release of 18 owls at Kilohana in 1959 through June 30, 1965. By the latter date, the owls had spread nearly around the island of Kauai, especially in the lowland areas. Barn Owls in Hawaii often roost and nest in small caves on steep cliffs. The owls are strictly nocturnal in behavior and I did not see any during my one night in the mountains. I would be surprised, however, if the species does not occur there, especially at lower elevations.

E. Order Passeriformes

e. Family Timaliidae, Babblers and Laughing-thrushes

6. Melodious Laughing-thrush, Garrulax canorus

Although it is a babbler, this bird has long been called the Chinese Thrush (Hwa-mei) in Hawaii. It is native to the Yangtze Valley in China and southward to Laos, and it occurs in Formosa. It was a favorite cage bird in Hawaii 80 years ago. Birds were sent from Oahu to be released on Kauai in 1918. Richardson and Bowles (1964) found this laughing-thrush to be "present from the coast to the highest forests (over 4,500 feet), and from humid forested valleys to dry, barren canyons of the southern Na Pali coast." I found this species in song along the course of the river.

7. Red-billed Leiothrix, Leiothrix lutea

Known in the cagebird trade as the Peking Nightingale and the Japanese Hill Robin, the Red-billed Leiothrix is not native to either region. The species is found in northern India, the Himalayas, Burma, and southern China. According to Caum (1933), the species was first imported from San Francisco for liberation on Kauai in 1918; birds from the same source were released on Oahu in 1928, and that same year other birds were imported from the Orient and released on Oahu. Richardson and Bowles (1964) wrote: "In curious contrast to its great abundance on Oahu and Hawaii, this species is generally very hard to find on Kauai. We saw nine or more in two groups in late July and early August above 3,750 feet on the outskirts of the Alakai Swamp native forest." Since the 1960s, however, the leiothrix has become a rare species on Oahu (Berger, 1981), and my own experiences on Kauai since 1965 confirm the observations of Richardson and Bowles, although I did hear two birds singing along the Hanalei River.

f. Family Turdidae, Thrushes and Bluebirds

8. Shama, Copsychus malabaricus

There are 17 subspecies of this thrush. These are native to Sri Lanka, India, Nepal, Burma, Malaysia, Vietnam, Laos, Java, and throughout Indonesia. Shama is the Hinde name for this species. It was released on Kauai in 1931. Richardson and Bowles (1964) found the Shama to be a "moderately common resident locally, usually in inhabited lowlands" on Kauai in 1960. They found it at Haena, Lihue, and Waimea, and in a mixed Albizia forest, a casuarina grove, and in kiawe, "thus showing much adaptability to habitats varying widely in vegetation and aridity." I found the Shama on Sunday, March 2, 1986, at the lower stretches of the Hanalei River. All of the nests that I have found in Hawaii have been built in tree cavities, but Richard C. Tongg found a Shama nest built in a pair of shoes on an outside shelf of a house in Wailua Homesteads, Kauai (Elepaio, 27:37). This confiding bird is much more common at lower elevations on Kauai.

g. Family Zosteropidae, White-eyes and Silver-eyes

9. **Japanese** White-eye, Zosterops j. japonicus

This race of the white-eye is native to the main islands of Japan, from Honshu to Kyushu and the islands lying between Japan and Korea. The first Japanese White-eyes (Mejiro) were released on Oahu by the Territorial Board of Agriculture and Forestry in 1929 (Caum, 1933). Caum thought that the species "was possibly established" on Kauai by 1933. The White-eye offers an example par excellence of the success of introduced birds. It now occurs on all of the main islands, is found from sea level to tree line on Maui and Hawaii, and inhabits very dry areas (e.g., Kawaihae, Hawaii) and those having 300 or more inches of rainfall per year. There is virtually no habitat in Hawaii that is not occupied by White-eyes, and I believe it to be the most abundant song bird in the islands. White-eyes eat insects, nectar, soft fruits, the pulp of berries, and buds, so that they can be a serious threat to farmers. The California State Department of Agriculture is greatly concerned about the accidental release of a related species (Gray-backed White-eyes, Z. palpebrosa) at San Diego. Two pairs escaped in 1973 or 1974; 150 offspring had been captured since then. "Estimates of the potential loss in soft-fruit crops, should white-eyes ever begin to multiply rapidly and establish a large population, run as high as $2 million a year" (Audubon Magazine, September 1982; see also Keffer, et., al, 1976). I found the Japanese White-eye at all elevations along the Hanalei River.

h. Family Sturnidae, Starlings and Mynas

10. Common Indian Myna, Acridotheres tristis.

The myna is native to Sri Lanka, India, West Pakistan, Nepal, and adjacent regions. The myna was introduced from India "in 1865 by Dr. William Hillebrand to combat the plague of army worms that was ravaging the pasture lands of the islands. It has spread and multiplied to an amazing extent; reported to be abundant in Honolulu in 1879, it is now extremely common throughout the territory" (Caum, 1933). This myna is common to abundant in lowland areas of the inhabited islands, being most common in residential areas and in the vicinity of houses and barns in outlying districts. Richardson and Bowles (1964) also found mynas roosting in fire trees behind Waiale cabin in the Alakai swamp at an elevation of 3,650 feet. I found the myna only in the lowest stretches of the Hanalei River.

i. Family Ploceidae, Weaverbirds and Allies

11. Spotted Munia or Ricebird, Lonchura punctulata

This Asian species was brought to Hawaii by Dr. William Hillebrand about 1865 (Caum 1933). Caum wrote that the Ricebird "feeds on the seeds of weeds and grasses and does considerable damage to green rice." Rice is no longer grown in Hawaii, but the Ricebird has recently become a serious pest by eating the seeds of sorgum (see under House Finch). The Spotted Munia is another abundant species in Hawaii, and it is tolerant of both very dry and very wet habitats. The birds tend to be nomadic during the nonbreeding season, moving over large areas in search of seeds. The birds are prolific, nesting in every month of the year. The birds occur from sea level to the mountains and, in the past, I have found it at Barking Sands and at Kokee State Park. The birds do not inhabit dense forests but are found along jeep trails and streams in the mountains. I saw several small flocks during my two days in the field.

12. House Sparrow, Passer domesticus

Also called the English Sparrow, the House Sparrow was first imported to Oahu in 1871, when nine birds were brought from New Zealand (where the species had previously been introduced from England). Caum (1933) wrote that "whether or not there were further introductions is not known, but the species was reported to be numerous in Honolulu by 1879." The House Sparrow in North

America (first introduced in Brooklyn in 1852) became a serious pest and tens of thousands of dollars were spent in attempting to control the population. (Dearborn, 1912). The House Sparrow apparently never became a pest in Hawaii; it is omnivorous in diet, eating weed seeds as well as insects and their larvae. This sparrow typically is found in the vicinity of man and his buildings and I did not see any until we were nearly down to the houses at the end of the road.

j. Family Fringillidae, American Sparrows and Buntings

13. Cardinal, Cardinalis cardinalis

The Kentucky Cardinal or Virginia Cardinal was released on Kauai several times between 1929 and 1931. By the 1960s, Richardson and Bowles (1964) found Cardinals in the very dry coastal areas of the Na Pali coast and in the very wet forests of the Alakai Swamp at elevations of nearly 4,000 feet. I found cardinals at all elevations along the Hanalei River that we surveyed.

14. House Finch, Carpodacus mexicanus frontalis

This finch is native to western North America; in recent years, however, the species has established populations in New York, Connecticut, Massachusetts, westward to Ohio, from captive birds that were released on Long Island. The House Finch was first brought to Hawaii "prior to 1870" (Caum, 1933). It now is an abundant species on all of the islands, in residential and urban areas, in both wet and dry rural areas, and in the high ranch and open forest lands on Kauai, Maui, and

Hawaii. Because of their fondness for overripe papaya, the bird sometimes is called the Papayabird in Hawaii. Despite their liking for soft fruits, however, House Finches are predominantly seed eaters, frequently also eating flower buds. When experimental crops of sorghum were planted in former sugarcane land on Kauai and Hawaii, the Chairman of the Board of Agriculture reported to the State Senate in 1972 that a study of the "bird problem in sorghum fields at Kilauea reveals that Metcalf Farms, Inc., is experiencing 30% to 50% losses due to feeding by large flocks of ricebirds and linnets" [= House Finches]. This loss was significant because of the implications for the success --or failure--of small grain crops in Hawaii, and the resultant effects on the cattle industry in the state. The losses to sorghum caused by the Ricebird and the House Finch at Kohala, Hawaii island, were even greater than those on Kauai. I saw and heard House Finches during both days of our trek down the Hanalei River.

Mammals

I. Endemic Mammals

The only endemic Hawaiian land mammal is the Hawaiian bat (Lasiurus cinereus semotus), a subspecies of the American hoary bat. The Hawaiian bat occurs primarily on the island of Hawaii, where it has been seen from sea level to 13,200 feet elevation (Tomich, 1969; Kramer, 1971). Bats have been seen along the road to Kokee State Park but there have yet been no studies of the distribution or behavior of this bat on Kauai. However, Jan TenBruggencate (1983) mentions a sick female bat at the Kokee Air National Guard station that had "two near-term fetuses"

(Star-Bulletin/Advertiser, May 1, 1983). Tomich (1974) discusses in detail what is known about the bat on Hawaii and the rest of the main islands. Based on his findings, it is reasonable to state that the proposed project would have no adverse effects on the endangered Hawaiian bat.

II. Introduced Mammals

All of these alien species have proven highly detrimental to man, his buildings, products, some of his agricultural crops, as well as to the native forests and their animal life. None, therefore, are of any concern as far as detrimental effects resulting from the proposed project. It would in fact, be a great boon to the islands if it were possible to exterminate many of these mammalian species.

Some of these mammals were first brought to the islands by Captains Cook and Vancouver. Feral cattle, goats (Capra hircus), sheep (Ovis aries), and pigs (Sus scrofa) have been destroying the Hawaiian forests since 1800, and they continue to do so today. Pig trails, wallows, and other signs were conspicuous at all elevations along the Hanalei River. In writing about the Kilauea forest on the Big Island, Mueller-Dombois et al. (1981)noted that this was "the best intact example of this forest type remaining in the state" and that "the effect of feral pig is very noticeable, and there is little doubt that the widespread pig digging in the Kilauea forest has been a major factor in reducing the native ground vegetation. The present total cover was estimated at only 7.7 percent. Pig digging undoubtedly has an effect on the invasion of exotic plant species. Several exotic grasses occurred sporadically in forest openings where the ground was disturbed by pigs." I did not see or hear any goats along the Hanalei River, and they may not occur there. They do occupy habitat north and west of this area (Telfer, 1984).

With the possible exception of the house mouse (Mus musculus), all of the smaller introduced mammals prey on birds and their nests and eggs. These small mammals include the roof rat or black rat (Rattus rattus), Polynesian rat (Rattus elegans), Norway rat (Rattus norvegicus), and the small Indian mongoose (Herpestes auropunctatus), as well as feral cats (Felis catus), and feral dogs (Canis familiaris). Because all of these mammals are serious pests, I did not attempt to set traplines to catch these nocturnal rodents; it is reasonable to assume that all inhabit this area (Tomich, 1969; Kramer, 1971). The diurnal mongoose is readily seen on the other islands, and, although mongooses were apparently sighted on Kauai several years ago, I was pleased not to find any in this remote area.

Conclusions and Recommendations

1. Because there are no endemic amphibians or land reptiles in the Hawaiian Islands, all of those that are present are alien or introduced species. None is an endangered species and none is pertinent to an environmental impact assessment. In fact, the bullfrog is known to be a predator on the downy young of the endangered waterbirds, and the neotropical toad is, because of

the poison glands on its back, a cause of poisoning of dogs that bite the toad.

2. The Hawaiian bat is the only endemic land mammal in the Hawaiian Islands. There is no evidence that the bat occurs in the Hanalei River drainage system. Bats feed on insects at night; on the island of Hawaii they are common in towns. Even if they should expand their range on Kauai to include the project area, The construction of a dam and penstock should have no effect on the bat (see Tomich, 1969, 1974).

3. All of the remaining mammals found on and adjacent to the project site are introduced species and all are serious pests to man, his activities and products, and/or to the native flora and fauna. The three species of rats prey on ground-nesting and even tree-nesting birds, and the mouse and the rats cause great damage to agriculture as well as to homes and industrial plants. And, as mentioned earlier, pigs cause great destruction of native forests. If it were possible to exterminate all of these alien mammals, it would be a great boon for the islands. Their presence, therefore, is irrelevant to an environmental impact assessment.

4. A similar statement can be made about the 14 species of introduced birds that I have discussed. The destruction of sorghum crops by the Ricebird and the House Finch has been mentioned previously. The doves and the myna have been implicated in spreading the seeds of noxious plants such as Lantana camara. The Japanese White-eye sometimes is a serious pest to fruit farmers. The Barn Owl has been shown to kill

seabirds on Kauai, and Cattle Egrets pose problems at the Lihue airport. Therefore, it seems reasonable to assert that these pest species are irrelevant to an environmental assessment.

5. The proposed project would have no effect on the two native shorebirds that I found along the Hanalei River on March 1 and 2, 1986. I found them along the Wainiha River despite its dams and power plant.

6. The chief concern about the proposed Hydroelectric Power project deals with its possible effects on the Hanalei National Wildlife Refuge at Hanalei. This refuge is classified as a "primary" habitat for most of the endangered Hawaiian waterbirds (Walker, et al., 1978; see, also, Byrd and Zeillemaker, in press). On May 1, 1986, I talked with Mr. Jim Krakowski, Wetlands Coordinator for the U.S.Fish & Wildlife Service, in Honolulu, about the current status of the birds at the Refuge. The Hawaiian Gallinule or 'Alae 'Ula (Gallinula chloropus sandvicensis) is the most common nesting bird in the Refuge. The first nest of the Hawaiian Coot or 'Alae Ke'Oke'o (Fulica americana alai) apparently was found on the Refuge during 1985. Only a few Hawaiian Stilts or Ae'o (Himantopus mexicanus knudseni) nest on the dikes separating the ponds; most of the stilts nest elsewhere on Kauai. Most Koloa spend much of the day feeding on the Refuge, and only a few nest at this low elevation. The first concern is that there might be a decrease in water flow to the refuge during construction and after the power plant is in operation. The second concern deals with the amount of

sedimentation that might reach the Refuge, especially during construction. If these engineering problems can be solved or alleviated, there is no reason that the proposed project should have an adverse effect on any endemic Hawaiian bird. Walker (1984) reported that no waterbirds were seen along the "Lower Hanalei River."

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APPENDIX IV

ARCHAEOLOGICAL RECONNAISSANCE OF UPPER HANALEI VALLEY HALELE'A, KAUAI BY HALLETT H. HAMMATT, PH. D. AND DOUGLAS BORTHWICK, B.A., OCTOBER 1986.

ARCHAEOLOGICAL RECONNAISSANCE

OF UPPER HANALEI VALLEY

HALELE'A, KAUAI

By

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Prepared for

BINGHAM ENGINEERING CO.

By

CULTURAL SURVEYS HAWAII

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ABSTRACT

An archaeological reconnaissance of upper Hanalei Valley was conducted October 1-5, 1986 to access impact of a proposed hydroelectric project. The survey area included over 5 miles of the river valley from Ka'apoko Stream to Hanalei Homesteads. Although the survey was constrained by heavy vegetation and steep terrain, 14 archaeological sites were located and briefly described. These occur on both sides of the river and are concentrated on the level point bars adjacent to the channel and probably extend upslope. Irrigated terrace sites, some with associated house platforms, were found throughout the project area. One of these sites may contain dry land terraces. The terraces may have been irrigated by water tapped from tributary streams rather than from the river itself. Historic house sites were found in the makai portion of the project area and correspond to those shown on a 1916 U.S.G.S. Map. There are 2 rock shelters upstream from the project area, one of which was visited by W. C. Bennett in 1929. Attempts to relocate and correlate to Bennett's sites were only partially successful. A more complete survey of a cleared and marked pipeline route including tributary intakes is recommended.

ACKNOWLEDGEMENTS

Many people contributed invaluable assistance to this reconnaissance. Mr. Clark Mower of Bingham Engineering provided coordination and support. Mr. Merv. Kimura of Island Power Co. on Kauai was also extremely helpful. Kenai Air Helicopters on Kauai provided helicopter transport and special recognition is due to Mr. Ron Williams, our pilot, for orienting us to major landmarks, landing us and picking us up with great skill and showing special interest in our safety by lending us a field radio. Ms. Winonna Char, Dr. Art Whistler, and Mr. Clyde Imata accompanied us on October 3 as part of their botanical survey. Mr. Charlie Okino of the State Survey Office provided us with the old Hanalei Quad map and other useful information. Drafting of Figure 3 was done by Mr. Steve Clark, and typing by Secretarial Service--by Mary of Kailua. We would also like to thank the Bishop Museum Library for allowing access to W. C. Bennett's field notes.

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I. INTRODUCTION

This reconnaissance is the first formal archaeological investigation of upper Hanalei Valley (Fig. 1, 2) since W. C. Bennett's 1929 survey. We are aware of the historical importance of this project and for this reason have attempted to record even minor details of the fieldwork. Our difficulty in interpreting Bennett's notes and site locations and making correlations of his sites to the sites we found underlines the importance of seemingly obvious details. To this end we have included improved field sketches of many of the sites. No doubt Bennett had the same difficulty in locating himself in these wild regions as we did and did not have the advantage of a helicopter and a locally knowledgeable pilot. However, we are now confident in the locations shown in Fig. 3 and consider the mapped trail and vegetation markers essential information for any future trips to the Valley. The 3500 foot gap in our survey will be filled in by a supplementary field trip when weather and time permit. This report is considered preliminary pending the completion of the survey gap. This should help clarify the questionable correlations to Bennett's site. In addition, the final report should include more documentation on the historical occupation of the makai portion of the project area and

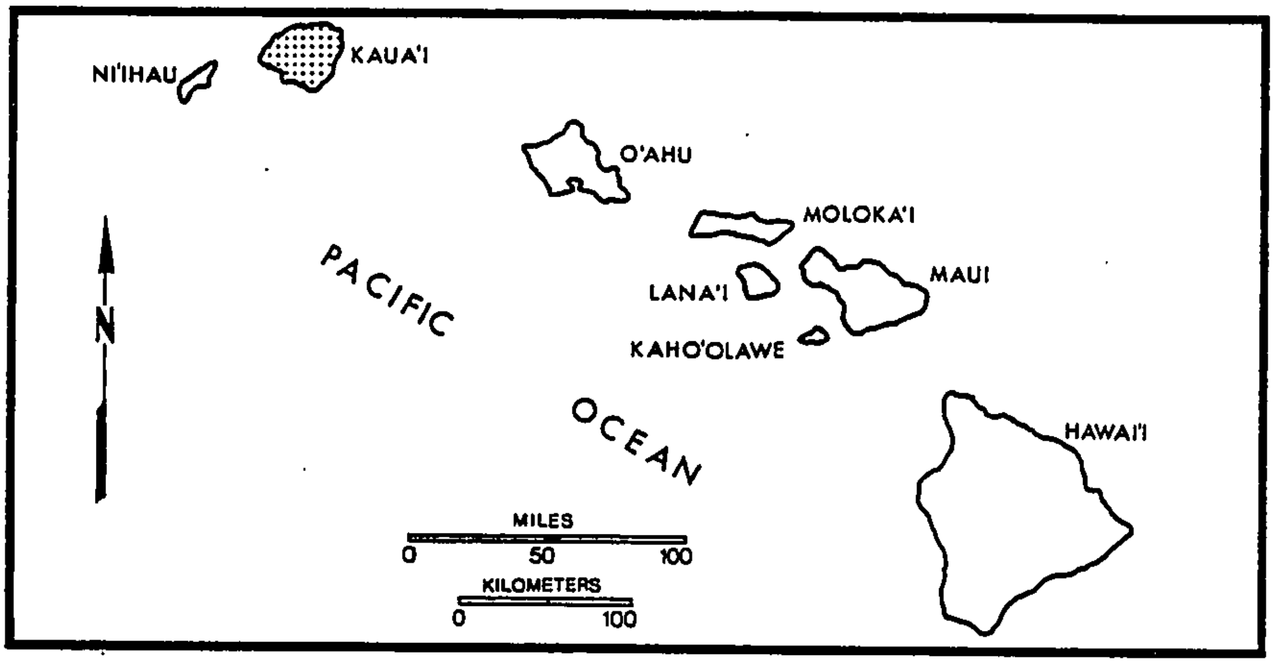


FIGURE 1
State of Hawai'i

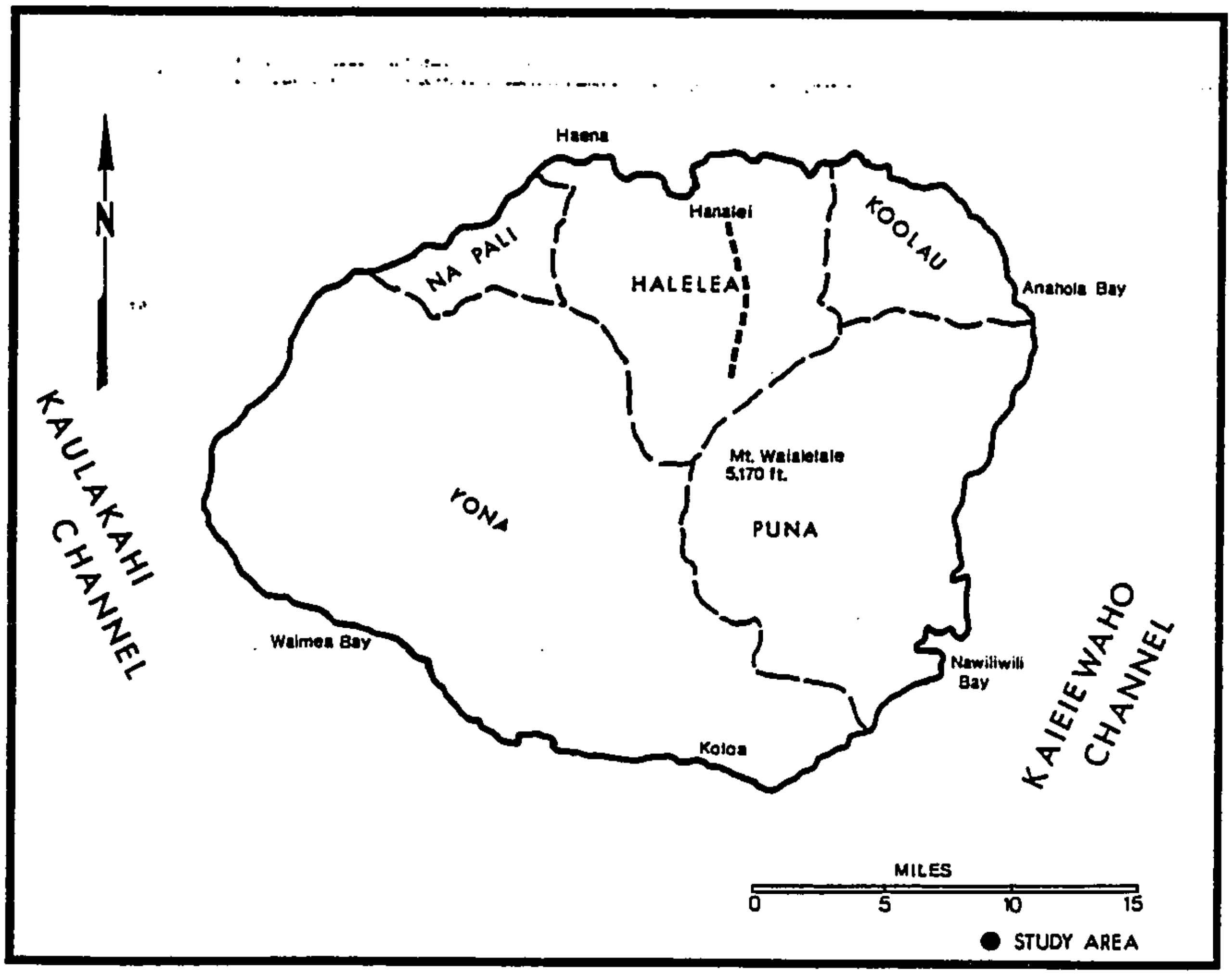


FIGURE 2
General Location Map, Kaua'i Island

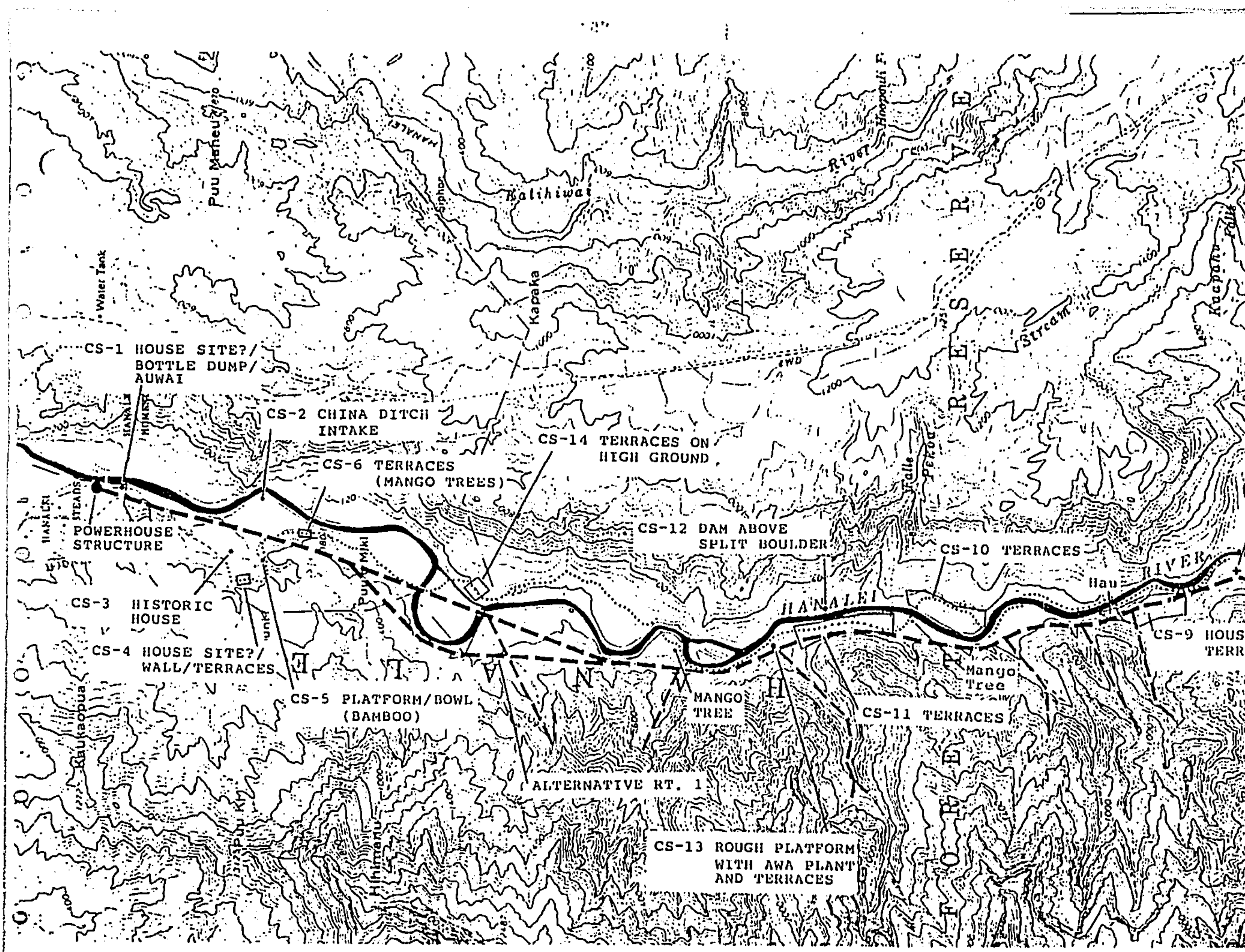
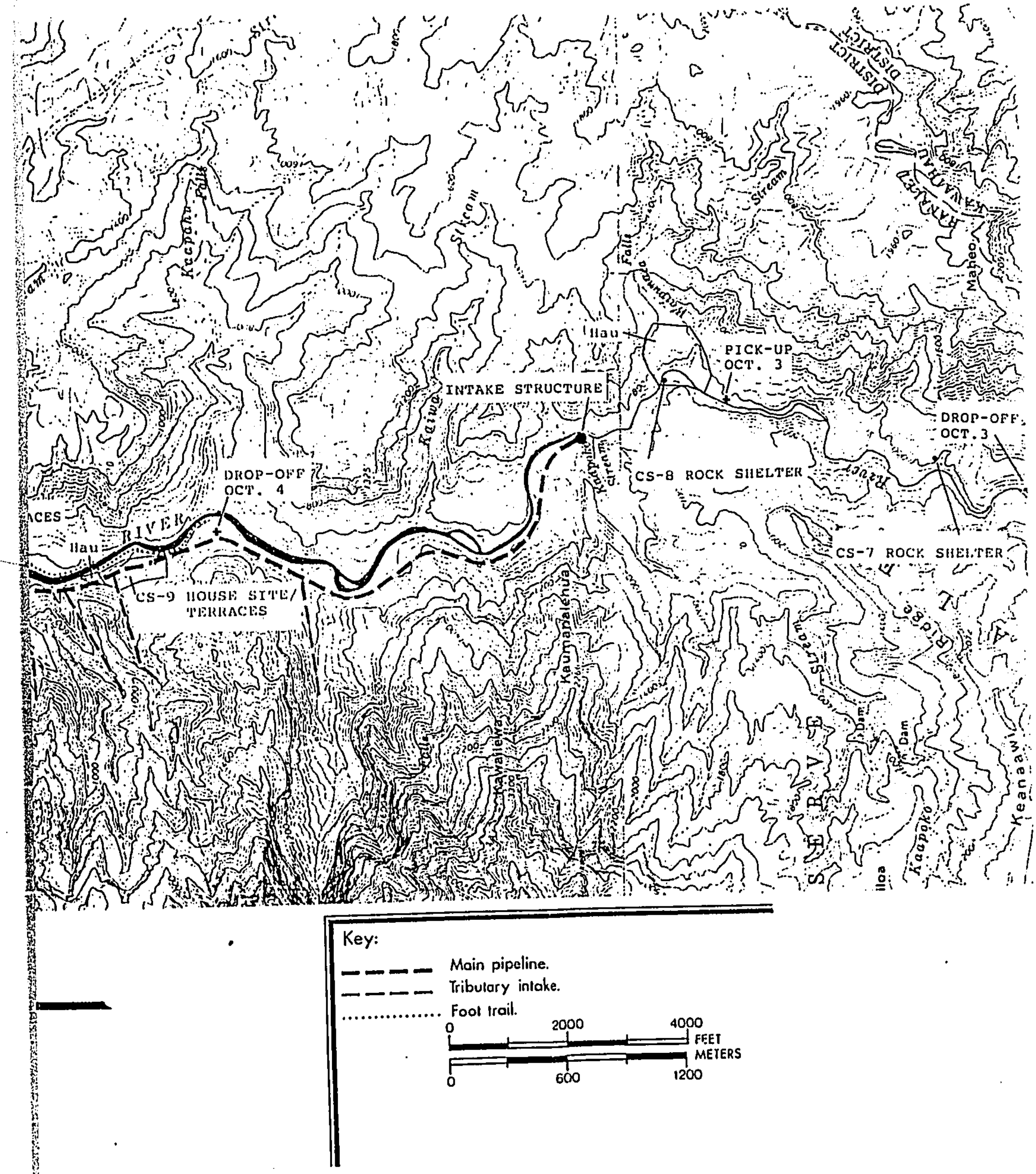


Fig. 3 Project Area Showing Archaeological Site Locations and Proposed Pipeline Route.


INTAKE STRUCTURE
PICK-UP OCT. 3
DROP-OFF OCT.3
DROP-OFF OCT. 4
CS-8 ROCK SHELTER
CS-7 ROCK SHELTER
CS-9 HOUSE SITE/ TERRACES
Hau
Hau
RIVER
DISTRICT
KAWAIHAU
HANALEI
Stream
Falls
Maheo
Kaumanalenua
Kawaiiewa
Kaapoko
Keanaawi
Ridge
Dam
Dam
Key:
Main pipeline.
Tributary intake.
Foot trail.
0
2000
4000
FEET
METERS
0
600
1200

more comparative information on Hanalei in general. There are still a number of unchecked potential sources including the Kauai Historical Society and location informants and we have still not been successful in locating Bennett's field map.

For planning purposes, the Summary and Recommendations sections at the end of this report are the most useful. Although information and new sites may be added, the recommendations will remain basically the same.

II. SCOPE AND METHODS OF THE PROJECT

This archaeological reconnaissance was conducted at the request of Bingham Engineering Co. of Salt Lake City as part of an environmental study for a proposed hydroelectric project in upper Hanalei Valley. It was originally conceived as a full scale survey but was scaled down to a reconnaissance in consideration of remote access, difficulty of terrain, and tentative location of the proposed pipeline route.

Basically, the plans call for a main pipeline with the intake at Ka'apoko Stream running a distance of over 5 miles on the west side of the river to a power generating structure at Hanalei Homesteads. In addition to this main pipeline are 7 proposed side intakes to tap water from tributaries on the west side of the river. These intake pipes vary from 2800 to 1270 feet in length.

In general, the reconnaissance concentrated on the route of the main pipeline with no systematic attempt to cover the side intakes at this stage. The assumption is that if archaeological sites were located at or near the main pipeline route at the bases of these tributary streams and if relatively level land is present on the tributaries, there is a good chance athat archaeological sites extend into these side valleys.

The scope of the reconnaissance was to locate and briefly describe archaeological sites within the main valley of the Hanalei River near or on the path of the proposed pipeline and more specifically to evaluate the impact of pipeline construction on these sites. The results of this reconnaissance are the main factor in determining if a more thorough survey is required before actual construction.

At present, the pipeline route and tributary intakes are simply lines on the U.S.G.S. Map. Given the impenetrable vegetation (particularly hau groves) in much of the pipeline route, there was no attempt to follow the exact route. The reconnaissance route with some exceptions was the trail. In many areas this was the only route up and down the valley because of steep ground, deep water and heavy forest. However, during the reconnaissance there was constant awareness of the general location of the pipeline in relation to the trail. When sites were found on the trail, there was an attempt to determine whether the site area extended to the pipeline route.

Because the trail crossed the river at regular intervals, some sections of the main pipeline were not covered. (Compare location of pipeline to trail on Fig. 3.) Similarly, in these areas the vegetation and flatness of the terrain, nature of tributary streams, etc. were noted to determine the probability of archaeological sites being present.

This project, with fieldwork undertaken Oct. 1-5, 1986, was preceded by a 2-day walk-through reconnaissance mauka to makai by the senior author on March 1-2, 1986. During this earlier trip few notes were taken and locating ourselves on a map was difficult or impossible. However, archaeological sites were observed from the intake structure makai. The only locational information recorded was approximate elevation and which side of the river the sites were on. This earlier walk-through was extremely valuable for the present project in underlining the difficulties and possible constraints of the next phase of archaeological reconnaissance. The most crucial problem was locating our position on the map, both on the ground and from the air, and properly locating and mapping a possible helicopter landing spot.

The lower portion of the project area to the large meander in Hanalei River south of Puu o Miki was surveyed by walking mauka from Hanalei Homesteads. Following this the archaeologists (and botanists) were landed by helicopter in the upper portion of the Valley in the morning and picked up in the evening. Unfortunately, there were only two suitable drop-off and pick-up points, and our attempt to locate these points on the map was in error. For these reasons, one day of survey was spent mauka of the project area. (See Fig. 3.) However, during this day two rock shelters were located. Following this, on October 4, and again limited by suitable landing places, the archaeologists were dropped off below the intake and surveyed makai. A separate helicopter flight was taken upon our return to correct exact locations of drop-off and pick-up points and site areas as well as to take aerial photographs. Our ability to achieve this was greatly aided by Mr. Ron Williams' (the pilot) close familiarity with prominent landmarks of the Valley. As a result, we are now confident of all locations on Figure 3. Unfortunately, there is a gap in the survey coverage of approximately 3,500 feet from Ka'apoko Stream (the location of the proposed intake structure) to the October 4 drop-off point. This gap is of particular concern because Ka'apoko may be one of Bennett's 1928-29 site areas. This gap in the survey will be completed when time and weather permit. Observations made during the March 1-2, 1986, walk-through indicate a good possibility of sites occurring in this area. Again, this survey gape underlines the difficulty in locating on the ground to even the most prominent landmarks in the steep terrain and dense vegetation.

III. DESCRIPTION OF THE PROJECT AREA

Hanalei Valley and its catchment basin forms the largest Ahupua'a (ancient land unit) in the Halele'a District of Kauai. This district with plentiful rainfall, and the most mature river systems in the Hawaiian Islands was in precontact times, as it is today, the largest wetland agricultural area in the State. At present, Hawaiian taro is cultivated only in the lower portion of the Valley below the Hanalei Homesteads. The area of this study extends through the now uninhabited upper portion of the Valley. At the proposed power plant structure the river is at elevation 40 feet extending to 540 feet elevation at the mauka end (Ka'apoko Stream). This is a slope of 500 feet over a river mile distance of approximately 5.9 miles. The river itself along this distance has meandered across an incipient floodplain whose widest points are little over 1,000 feet. The inside of the curves form point bars which vary from 800 to 2000 feet in length and become broader and more level downstream. In some cases, these point bars are cut along their backs by intermittent flood channels of the river. In the upper sections of the project area there are two major islands in the main channel.

Hanalei is a wet valley. It drains a plateau in its upper reaches with rainfall exceeding 500 inches yearly. The Valley itself has rainfall from 300 inches at the top to 150 inches near its mouth. There is plentiful evidence of seasonal flooding throughout the Valley. The channel during a flood stage has changed course in at least one place since the 1983 USGS Quad map was completed and has cut off the wide meander mauka of Pu'u o Miki, forming an island. Other channels behind meanders show signs of frequent carrying of overflow. During flood stage prominent islands are completely under water. Flood debris was found in tree branches 8 to 10 feet above normal water levels during the March 1-2 visit to the Valley.

TRIBUTARY VALLEYS

The configuration of the tributary valleys and the contrast between those on the west side and east side is partly determined by differing ages of volcanic series. The Valley is formed through the contact between the older Olokele Formation on the west side and the younger (Pleistocene) Koloa Series on the east side (Macdonald and Abbott: 1970). The ridge on the west side is higher and the tributary valleys generally steeper. However, the Isohedral liner show higher rainfall on the west side (Armstrong, ed. 1973), particularly in the upstream areas. For this reason, although the westerward tributaries are shorter, they appear to carry more drainage.

Larger tributaries typically head at steep "Pali-like" cliffs with waterfalls. These side valleys broaden at their confluence with the Hanalei River but still maintain steep sides. The only reasonable access on foot up these valleys would be up the stream bed itself and even then only for short distances.

Some of these tributaries are named. On the east side makai to mauka are Pekoa, Kaapahu, Kaiwa and Waipunaea. All of these streams have falls and all look fairly similar from the air. (This fact in part led to the mislocation of the upper limit of our survey area on October 3.) Waipunaea Valley supports a dense hau forest at its lower end which is an easily visible marker from the air.

On the west side the valleys are short, steep and unnamed on the U.S.G.S. Map, except for Ka'apoko at the mauka end. This valley is by far the longest on the west side of the river. Its flow is dammed high in the valley and diverted through a tunnel to the Hanalei River and then tunnelled to the Wailua drainage. An unnamed valley on the west side, opposite Kaapahu Valley, is a prominent marker from the air. It has a steep back with three high falls.

It is of possible historical and archaeological interest that only the longer less steep valleys have names. These are the most likely side valleys to have been used or even settled by ancient Hawaiians.

VEGETATION

It is unlikely that the soil moisture on the valley bottom and in other level areas near the stream ever drop far below holding capacity. Boggy conditions are the norm and surface rivulets flow freely even in comparatively dry periods. Water stands in most all stream overflow channels and drips from most rocky slopes, and small streams flow even where no drainage is indicated by the topography. The vegetation growth is correspondingly lush. The mature tree growth is found only in the broader point bars in the lower reaches of the project area. Guava, lantana, tree ferns (hapu'u), Jobs Tears, hau, tall exotic grasses, ginger cover most of the low-lying areas with occasional Kukui trees. Ohia lehua and uluhe fern cover the higher slopes.

No comprehensive plant list was compiled for this archaeological survey. However, the vegetation has significance to our work in two aspects: 1) its density prevented definition of site area boundaries and may have totally hidden some site areas from discovery as well as constraining the survey area to the trail and adjacent areas; 2) the occurrence and distribution of introduced economic species in the Valley is an indication of Hawaiian land use.

Mango trees isolated and in groves in the makai area occur along the trail to near house sites - CS1, CS3, CS4, CS5, CS6. Some isolated trees extend upriver nearly to Pekoa Stream. Mountain apple trees were observed only in makai areas.

Bamboo also occurs as dense groves in makai areas from CS5 northwards. A thick grove of awa covers a rough platform at CS13 and was almost certainly planted in place by aboriginal Hawaiians. Feral banana, taro and ti grow throughout and even far above the project area. Wild taro was seen along the river at 1250' elevation during the March 1-2, 1986 walk-through. Also worthy of note is the dense hau forest at the base of Waipunaea Stream. Its presence could indicate previous land disturbance. The presence of lantana throughout and even above the project area is also a sign of land disturbance by wild pigs and marijuana growers.

THE TRAIL

As would be expected, the Hanalei Valley trail is clear and fairly frequently used in the makai section, becoming more difficult to follow mauka. The 1910-1916 U.S.G.S. Map marks the trail mauka only to Kaapahu Stream and today it appears to be maintained approximately to this point. However, there have been changes in the route of the trail from 1916 to the present except in the area of Hanalei Homesteads. The trail was certainly well developed for a long time and was the main access to the settlement shown on the 1916 map (Fig. 4). In the mauka areas the trail route must have changed in places with the constantly changing configuration of the river itself. With this consideration it is believed that the trail is ancient because the river side was the only possible access to upland settlements and taro fields. The trail traverses the flattest land on either side of the river with four crossings of the river from Site CS9 makai. In many cases the trail is the only possible route. These level point bars are also where the archaeological sites occur. All of the sites except for CS12 were found along the trail, but there are probably other site areas hidden in dense vegetation. The stepped field terraces at sites CS9, 10, 11, 13 were easily discerned as man-made walls where the trail crossed them at regular intervals.

Mauka of the CS8 rock shelter, the trail is barely discernible in spite of clear evidence of occasional use by pig hunters and marijuana growers. The rock shelter site (a hard, but possible one-day walk from the base of the trail at Hanalei Homesteads) may define the upper limit of ancient permanent settlement and taro cultivation within the Valley. The Valley narrows and the stream gradient increases. These factors may have precluded irrigated crops beyond this point. However, the value of even small areas of wetlands to aboriginal Hawaiians in late prehistory should never be underestimated. It is of

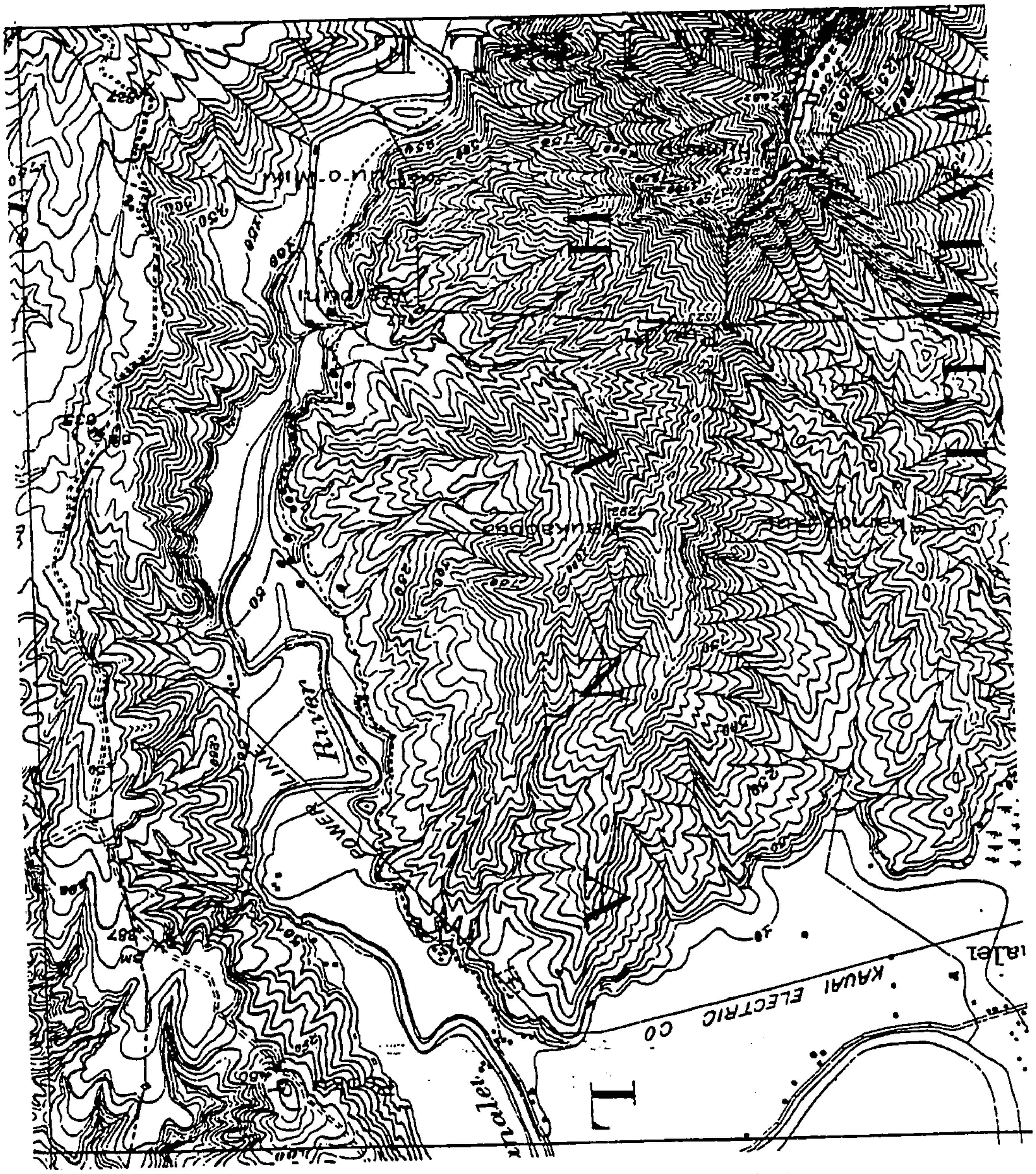


Fig. 4. U.S.G.S. Quad Map 1910-1916 showing house sites in project area.

interest to note that when Bennett stayed overnight at the CS8 rock shelter, he mentions informant reports of archaeological sites upstream. None were observed on this project or on the March 1-2 walk-through. This is not to say that sites are not present on the terraces above the stream bed.

IV. HISTORIC AND ARCHAEOLOGICAL BACKGROUND

Hanalei Valley represents the largest <u>Ahupua'a</u> in the District of Halele'a on the Island of Kauai. <u>Ahupua'a</u> refers to the traditional land divisions that were basic units of social, economic, and political life in the pre-contact Hawaii.

> "Ideally an <u>Ahupua'a</u> land section stretched in a wedge from its apex at a mountain top to its base in the sea, thereby including within its boundaries all environments necessary for a self-sustaining community. Again ideally, the inhabitants of an <u>Ahupua'a</u> were related by blood and through children, and could claim some degree of relationship to the chiefly family to whom the <u>Ahupua'a</u> had originally been assigned." (Barrere 1970:3)

The traditional or pre-contact period is not well documented for Hanalei Valley, especially the upper portions of the Valley. However, recent studies, beginning with Earle (1973) and including Cleghorn (1929), Schilt (1980), and Athens (1983) produce a general outline or probable pre-contact sequence.

I. Initial settlement period; possibly around the 6th or 7th century A.D. This period was probably characterized by a coastal settlement with a marine oriented economy; however, there was probably some habitation and the beginnings of agricultural activity in the lower Valley.

The evidence for this is an A.D. 660±95 date at Site D10-12 (Schilt 1980), which, as secondarily deposited charcoal "is suggestive of burning for forest clearance for shifting agriculture" (Athens 1983:31)

II. Semi-permanent to permanent settlements: This period was probably characterized by expansion of resource bases to both a marine and agricultural resources with permanent habitational sites in the Valley. The evidence for this is also from Site D10-12 where a stone tool assemblage, three possible post molds, and basaltic glass artifacts were found. The number and diversity of the artifact assemblage suggest permanent habitation dating to around the 13th and 14th centuries A.D. (Athens, 1983).

III. Permanent settlements and intensive irrigated agricultural complexes: This period would be characterized by expansion of high yield, possibly surplus oriented, pondfield taro production. Permanent settlements or house sites would be on non-irrigated lands, knolls, ridges, etc., which were not "prime" agricultural areas. This period, ca. A.D. 1500 to contact, probably saw expansion into an intensive use of upper Hanalei Valley, as evidenced by the number of sites reported by Bennett and seen on the present reconnaissance. The intensive use of the upper valley was possibly not until late in this period, ca. 18th century A.D., as prime lands, wide alluvial floodplains, would have been used first.

The post contact period in Hanalei has been relatively well documented in a number of historic sketches. These include E. H. Wilcox (1917), Earle (1973 and 1979), Hammatt and Folk (1979), Schilt (1980), and Carol Haraguchi's work in relation to the placement of the Haraguchi Rice Mill on the State Historic Register and making it a museum. Schilt offers the most concise historic background sketch, and the following is a short summary of that work (Schilt, 1980:5-8).

In general, foreign influence started in 1816 with Dr. Schaffer, a Russian, getting the deed to Hanalei Valley. However, this was very short-lived. In 1824 Kauai comes under the contact of the Kamehameha dynasty with Hanalei being held in trust for Liholiho. In 1834, the first mission (American Board of Missions) on the windward side of Kauai was established at Waioli. Also in the 1830's foreign plantations of sugar, silk and coffee were started and by the late 1840's there was approximately 1,000 acres of Hanalei in coffee. Population declined during this period, with the area experiencing low birth rates and moderately high death rates. The late 1840's saw shipments of goods to California, especially oranges, for the increased population there, which was due to the "Gold Rush." In the 1850's there was a drought and blight, which damaged the coffee crops. This was the time of the major land redistribution termed "The Great Mahele." From the 1860's to early 1900's population began to increase, due mainly to the influx of Oriental laborers for the large plantations. During this time, taro, coffee and sugar were being replaced in Hanalei Valley by rice, which was not only for local consumption but exported to the western continental United States. As the price of rice fell, due to cheaper foreign competition, taro, as a cash crop, made a comeback. Presently there are about 12 tenant farmers growing taro on the broad floodplain in lower Hanalei Valley.

ARCHAEOLOGICAL BACKGROUND

Archaelogical investigations of Hanalei began with W. C. Bennett in 1928-29 as is reported in Archaeology of Kauai (1931). Bennett lists five sites - 139, 140, 141, 142, and 143 as being within the Ahupua'a of Hanalei. Sites 141, 142, and 143 are described, in their relation to the present reconnaissance, in a separate section of this report.

"Site #139: Po'oku Heiau, on the east bluff of Hanalei Valley a short distance from the government road on a knoll marked on the map as Po'oku. Only a few stones remain to mark the location of this heiau which Thrum describes as "An unenclosed heiau of about two acres in area. Of Luakini class, terraced down on all sides from the central platform." (Ibid. 134)

Site 140: Kapaka, on top of Kapaka Hill on the east bluff of Hanalei Valley just within the forest line. Thrum describes this structure as "A paved open platform heiau without walls; stones set edgewise traverse through. Kane its Diety. Said to have had connection with Kapinao at Waiakalua in its workings." This side has had many stones removed, or covered over with vegetation. The river stones seem to cover the top of the hill for a diameter of 75 feet. The extent of the heiau could not be accurately determined. The stones set edgewise traversing through could not be found." (Ibid: 134).

Other archaeological work includes Earle (1973) and (1978) which dealt with the Halele'a District in general. The emphasis of his work is on irrigated agricultural complexes and their implications to social organization. The 1972 statewide inventory of sites located four sites, two fishponds, an auwai, and the Russian fort, Fort Alexander, in the makai area of Hanalei Valley. In 1979 Cleghorn conducted an extensive survey of most of the Hanalei Wildlife Refuge. The survey reports some twelve (12) sites both of prehistoric and historic age determinations. In 1980 Schilt conducted survey and test excavations, in "specified" areas of the Wildlife Refuge, "to determine the potential impacts upon archaeological resources of the proposed construction of an irrigation pipeline and access roads in the refuge." In 1981, Hammatt, Ida, and Folk conducted a survey of Kamo'omaika'i Fishpond at the mouth of Waile'ia Stream, where it enters Hanalei Bay, next to Hanalei River. Ths fishpond was one previously located in the 1972 Statewide Inventory KA-D10-9. In 1983 Athens conducted archaeological excavations at Site KA-D10-12, first located by Cleghorn in 1979, then tested in 1980 by SChilt. Athens' work "revealed two stratified pondfield layers . . . The lower layer . . . produced three late radiocarbon dates, indicating that pondfield construction and use occurred during the 18th century." (Athens 1983:i) Also "Basaltic glass samples from this lower layer date to the late 13th and early 14th centuries, indicating an occupation prior to pondfield construction." (Ibid.)

V. RECONNAISSANCE RESULTS

Each of the sites found in this reconnaissance is described below with field sketches included. Photographs of some site areas are included in the Appendix. For Site Locations, see Fig. 3.

CSH #1 (Fig. 5) is a probable historic house site, with historic trash covering an area of approximately 80 feet in diameter. This site is situated on a relatively steep soil slope heavily forested in bamboo. There are rusted pots and pans as well as bottles and broken glass. No distinct rock alignments were observed with the trash, though water rounded boulders were present in association with this site area.

Downslope (towards Hanalei River) from the trash area are two parallel ditches or auwai. The upper auwai ranges in width from 3 to 4 feet and is about 1.5 feet in depth. A water rounded boulder and soil embankment mark the downslope side of this auwai, with a mounded soil embankment on the upslope side. Downslope, some 100 feet, from the upper auwai, is the historically used auwai "China Ditch." China Ditch is cut into the Hanalei River bank with the side facing the river built up 2-4 feet high with soil and water rounded boulders. The China Ditch ranges from 5 to 7 feet across and 3 to 4 feet deep.

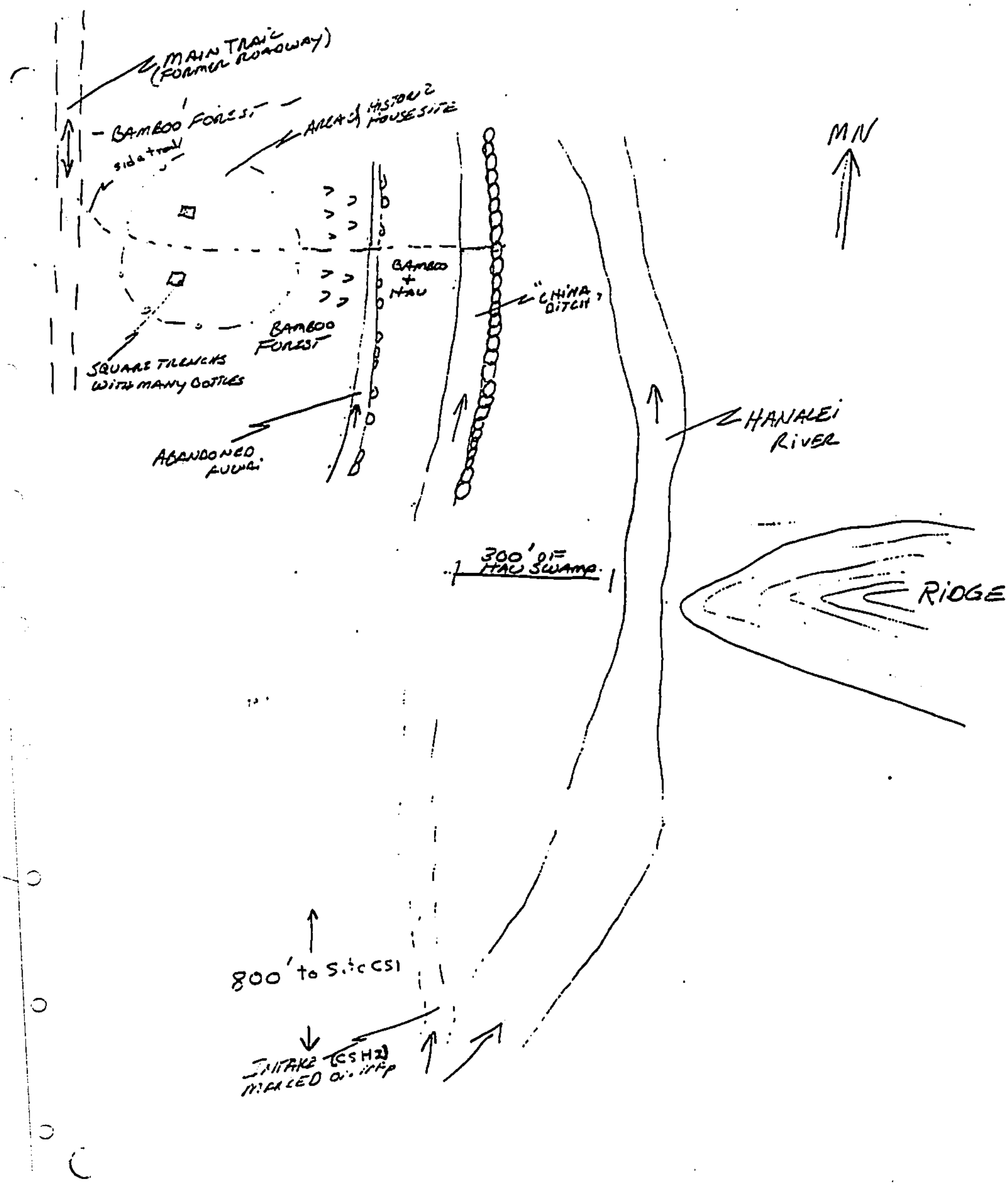


Fig.5 Field Sketch of Site CSH 1.

In association with the historic house site area were two rectangular excavations. The excavations were 3 to 5 feet long by 2 to 3 feet wide and up to 3 feet deep. These excavations are thought to be bottle hunters digs, as bottles and broken glass were especially plentiful near the holes. Bottles observed dated to ca. 1920's or later. The trash site area, CSH #1, was possibly associated with the maintenance and/or use of the historic auwai, China Ditch. This house site area is evident as a dot, in the approximate location, on the 1916 USGS Map (Fig. 4). Though the bottles observed seemed to postdate 1920, early bottles were probably removed or are not visible as surface remains.

<u>SITE CSH #2</u> (Fig. 6.) is the intake area in Hanalei River, for the presently used auwai, China Ditch. The intake area features two boulder dams. The larger dam (60-70 feet long) or water diversion structure extends into Hanalei River, from the west bank, diverting a portion of the river to the ditch. The smaller dam (20-25 feet long) acts as a water control structure, allowing a certain amount of water into the ditch. This small water control dam cuts across the opening of the ditch and is constructed of piled boulders with black plastic added as reinforcement to help control flooding and damage to the ditch.

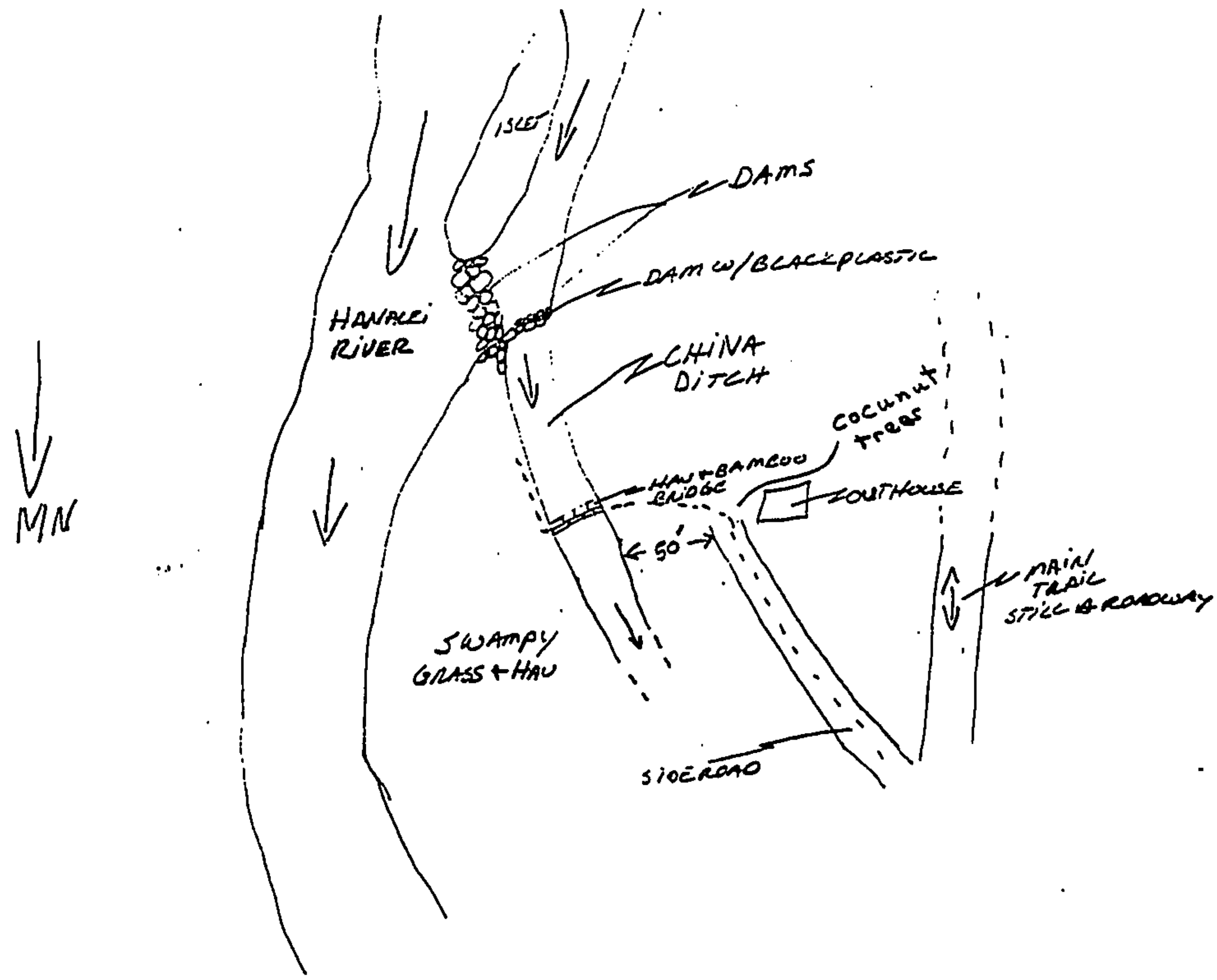


Fig.6 Field Sketch of Site CSH 2.

SITE CSH #3 is a possible historic house site. Associated with this site are three very large mango trees, with barbed wire nailed to their trunks, bottles, cans, other trash, and some large rounded basalt boulders. The boulders are not in any distinct alignment but could be evidence of a heavily disturbed house site. The barbed wire was part of a fence line and small enclosure or gate structure at this point of the Hanalei Valley trail. The bottles and other trash appear to be ca. 1920's or later. This site is probably associated with cattle grazing as there is good pasturage to the west of this site. However, the 1916 USGS Map (Fig. 4) also shows a dot at the approximate location of this site indicating the presence of a house site in 1910 when the actual fieldwork for the 1916 map was done.

SITE CSH #4 (Fig. 7) is a probable habitation enclosure and associated agricultural terraces. The enclosure measures 30 feet north/south by 20 feet east/west. The walls of the enclosure range from 2 to 3.5 feet in height and width and are constructed of stacked water rounded boulders. The interior of the enclosure is a relatively level soil surface with some exposed boulders. There are two terraces to the north of the enclosure which parallel the north wall of the enclosure. These terraces are boulder alignments 1 to 2 feet high and 15 feet long.

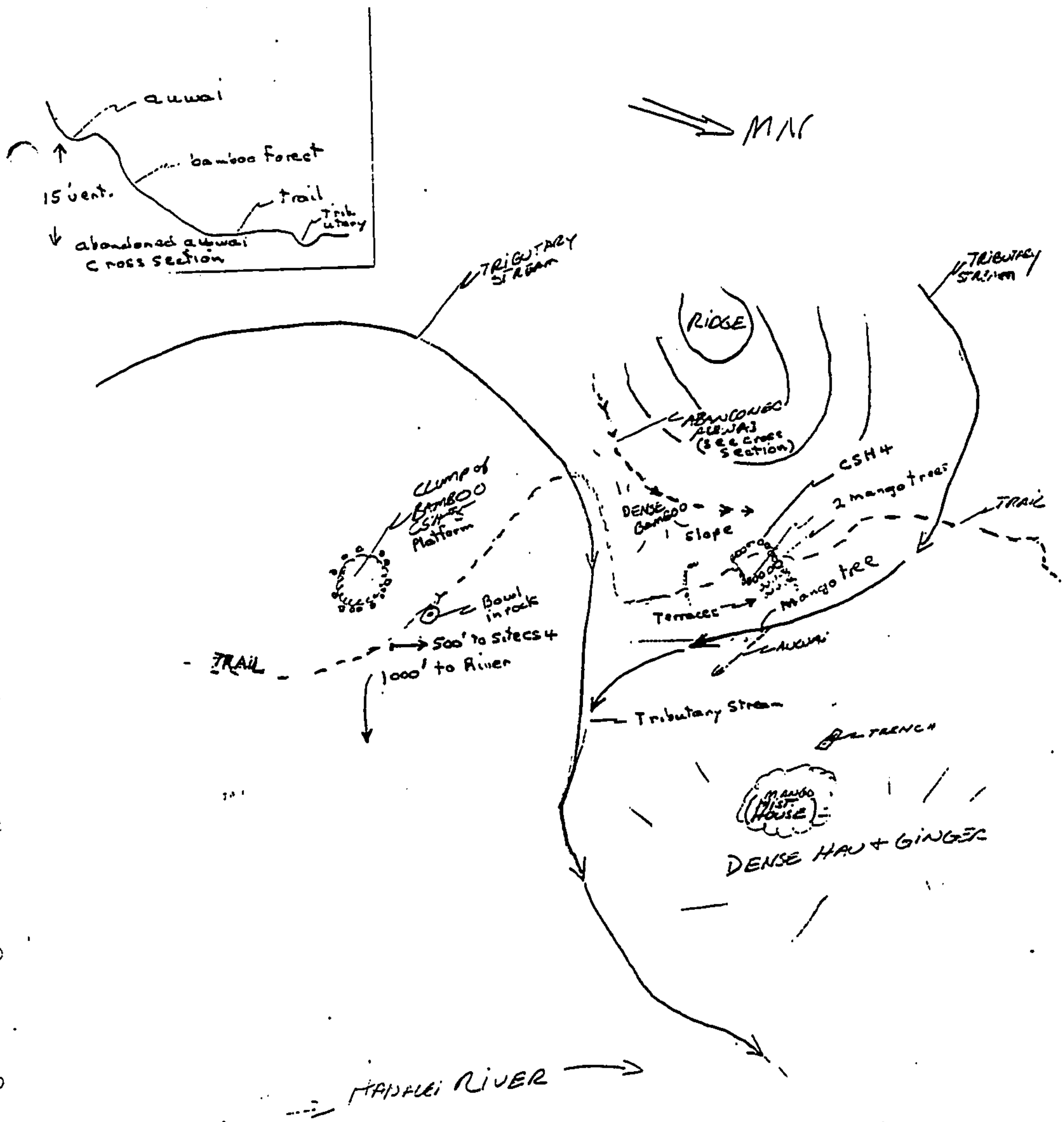


Fig. 7 Field Sketch of Site CSH 4 and 5.

Other, probable agricultural terraces, to the west of the enclosure, are barely discernible with only small sections, 10 feet or less, observed. However, to the southwest, on the slope above the site is a possible auwai. The auwai is approximately 15-20 feet above the surrounding terrain, cut into the steep slope of a small tributary stream bank.

The entire site is situated between two small tributary streams, then converge below the site, then enter Hanalei River. In the area between the site and Hanalei River (1000 feet) are a possible auwai and a possible historic house site.

The auwai extends for a short distance, approximately 100 feet, from the easternmost tributary towards the Hanalei River, then gradually flattens out and becomes indiscernible. The auwai averages 3 to 4 feet in width and depth, has steep soil sides and is not mounded or lined with rocks. This auwai may have acted just as a flood control outlet, or overflow type structure.

The possible historic house site is actually a few boulders around a very large mango tree with a few whole and broken bottles present. The area of boulders and bottles is 15 feet in diameter with no discernible rock alignment. The bottles observed were ca. 1920's or later. Also there was a rectangular trench 20 feet to the southeast of the mango tree. The trench measured 3 by 15 feet and 4 feet deep with the excavated dirt mounded along the sides of the trench. The trench is probably from bottle hunters, but other possibilities include latrine or outhouse excavation. This house site area also appears on the 1916 USGS Map (Fig. 4) as a house structure as does the above mentioned probable habitational enclosure.

SITE CSH #5 (Fig. 7) is a possible platform structure along the Hanalei Valley trail. The site consists of a slightly elevated area (1-2 feet) with boulders and cobbles visible but forming no discernible alignments. On the site is a large clump of mature bamboo with the rocks barely visible at and around the base of the clump. The area is approximately 25 feet in diameter on relatively level ground.

Associated with this site is a large boudler, 2.5 to 3 feet in diameter, which has a bowl shaped depression on the top. (See photographs in Appendix.) The boulder is located some 50 feet to the northeast, on the Valley trail, from the platform structure. The depression on the top of the boulder has been purposefully pecked into the rock and is about 1/2 foot in diameter and 1/2 foot deep with a very smooth interior surface. The rock, though large, may have been utilized as a "stone camp" as the depression is somewhat similar to those described by W. G. Bennett (Bennett, 1931:72). However, Bennett also located and described a large boulder with a circular depression on the top, from Kapahi, Kapaa, Kauai, that has similar characteristics. First it was found up a valley in association with taro terraces and house sites, and secondly it was large enough to indicate that it was not moved very far or often. The differences are in size of the boulder itself, much larger than the present Hanalei example, and also the depression was 1.7 feet in diameter and 9 inches deep compared to the .5 feet in diameter and depth of the one in the project area. This site area also appears as a dot on the 1916 USGS Map (Fig. #4) indicating that it may be historic in nature, though a pre-historic component cannot be discounted.

<u>SITE CSH #6</u> (Fig. 8) is a probable agricultural terrace wall remnant. The terrace wall is L-shaped, with the long leg approximately 25 feet, being parallel to the Hanalei River, and the short leg extending 10-15 feet westward off the south end of the long leg. The wall is a maximum of one foot high and is visible as a single alignment of water rounded boulders. The wall remnant is located between two large mango trees which have barbed wire strung between them. The wire fence is an extension of the cattle fence noted in CSH #3 description.

The wall remnant is approximately 100 feet west (up slope) of the Hanalei River with swampy hau forest in the area between the river and the wall.

<u>SITE CSH #7</u> is a rock shelter mauka (south) of the

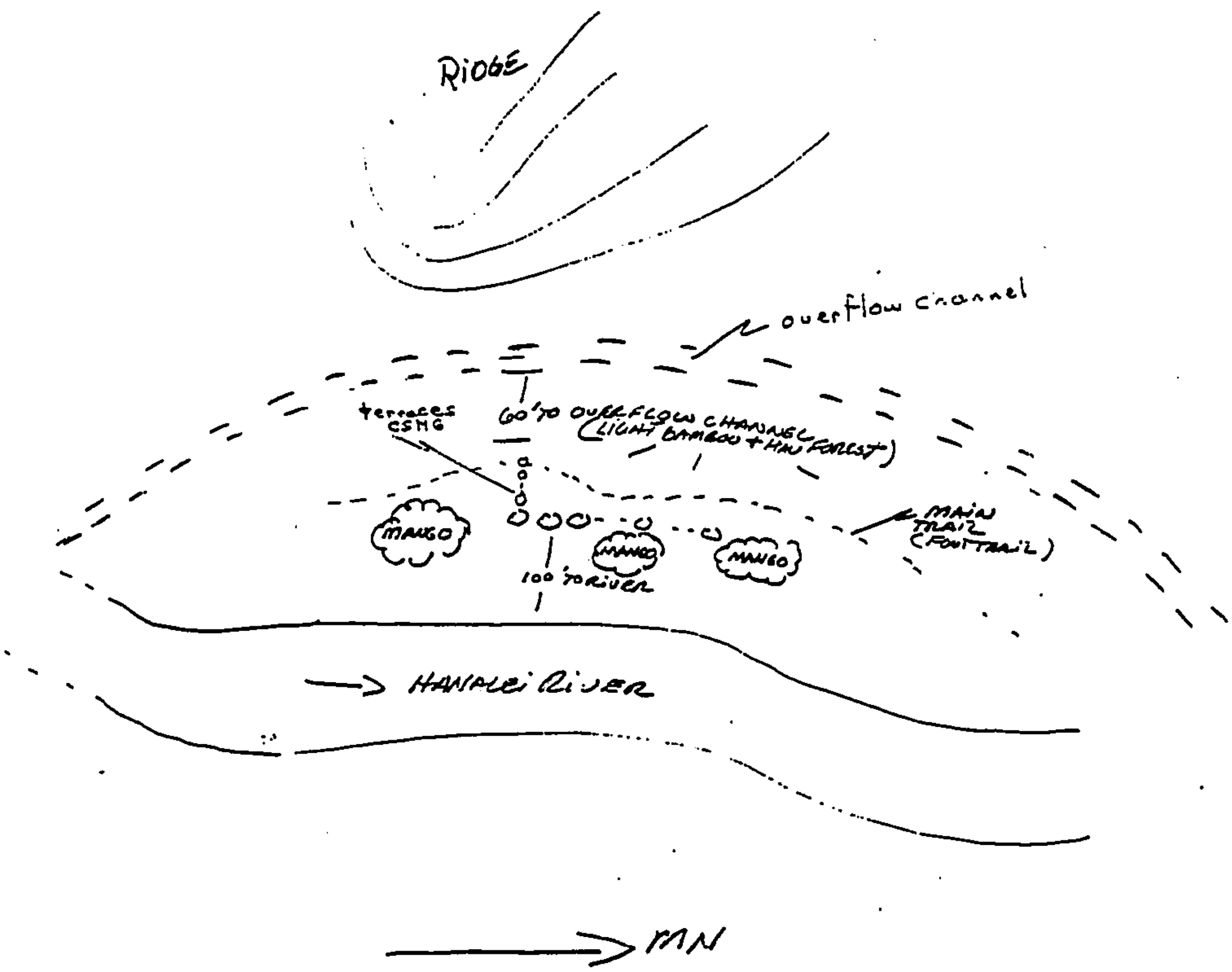


Fig. 8 Field Sketch of CSH 6.

project area. It is roughly 8 feet by 10 feet with ceiling height from 4 feet to 2 feet. The floor of the shelter is relatively level soil. Presently the overhang shelter is utilized by pot growers as evidenced by the paraphernalia left there. The shelter, although relatively dry from rain, during times of flooding could be at stream level.

A test of the soil in the shelter area indicated no subsurface cultural layer. This site was probably not a pre-historic shelter of long term use.

<u>SITE CSH #8</u> (Fig. 9) is a large overhang rock shelter mauka (south) of the project area. The shelter is 15 feet from front to back (N/S) and 25 feet wide (E/W). Ceiling height varies from 8 feet at the front to 3.5 feet at the back. The floor is a compact soil surface with some stacking of boulders along the front. The shelter is approximately 40 feet above the Hanalei River with an excellent view downriver (north).

Presently the shelter is heavily used by hunters and probably pot growers. There is fishing and trapping equipment, like bamboo poles with lines and hooks, wire mesh rectangular fish or prawn traps, as well as canned goods, pots and pans, grills, tarps, whiskey bottles, and bags of trash dumped over the side. There are clothes and other personal gear also.

This site has good excavation potential, in spite of the historic disturbance. A small probe into the soil

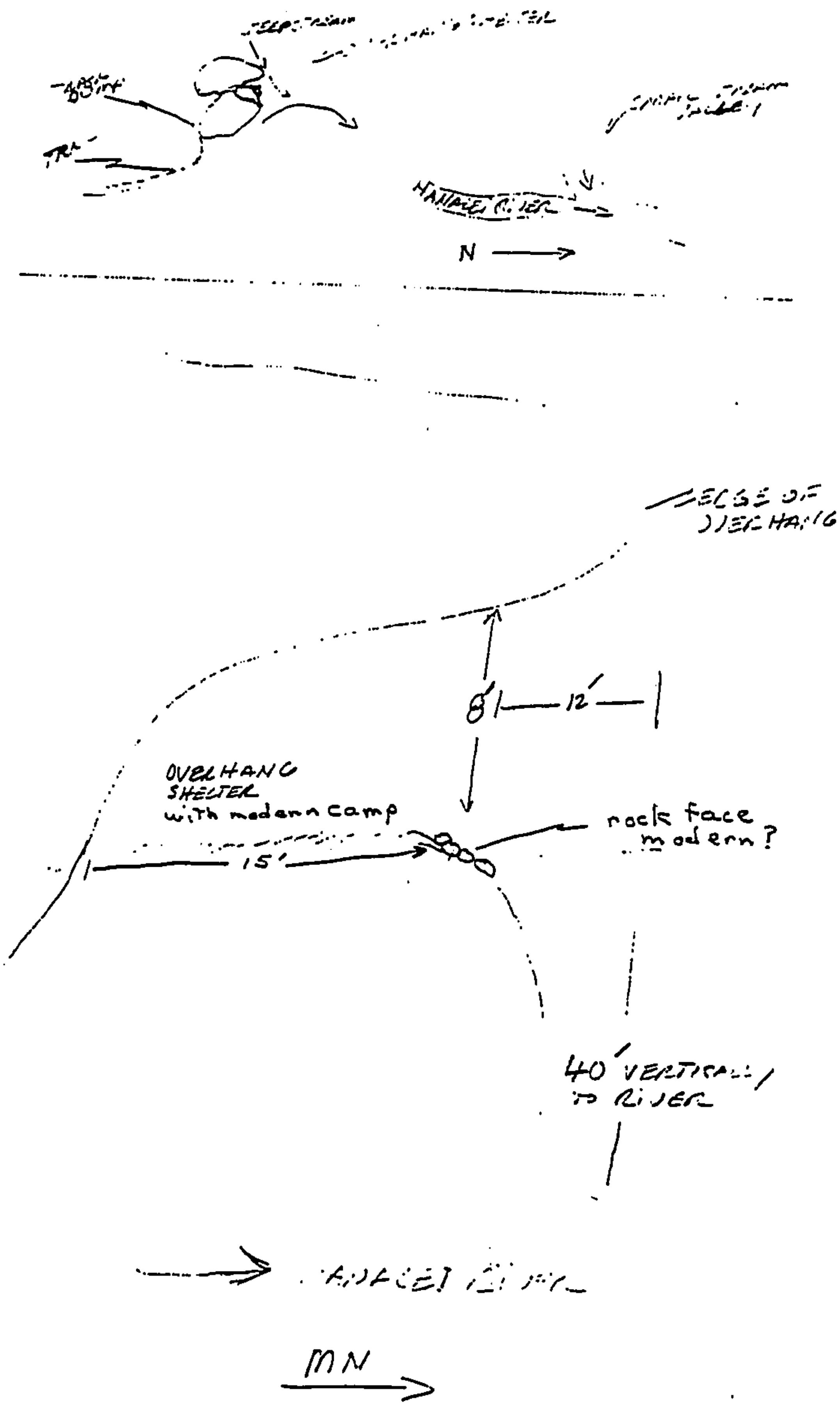


Fig. 9 Field Sketch of Site CSH 8.

floor indicated the presence of charcoal below the surface, though it could be from the historic use.

SITE CSH #9 (Fig. 10) is a complex of agricultural terraces and at least one house site. The complex covers an area of approximately 400-600 feet east/west by 800-1000 feet north/south. The visible terrace walls range in height and width from 1-3 feet and delineate rectangular fields or l'oi. The fields are oriented with their long axis parallel to the Hanalei River. However, it appears that the fields are not watered from the river but from a tributary stream which marks the northern extent of the complex.

The possible house site observed was heavily disturbed by kukui trees, but it appears to be roughly square in shape with maximum dimensions of 20 x 20 feet. The northeast corner is still relatively intact and shows construction of stacked boulders to a height of 1.5 feet. (See photographs in Appendix.)

In the area of Site CSH #9 complex, Hanalei River gradient seems less steep and the river broader and slower, than any sections of the river observed mauka (south) of the project area.

SITE CSH #10 is an agricultural terrace complex on a river plain on the east side of Hanalei River. There are a minimum of eleven (11) terrace walls delineating

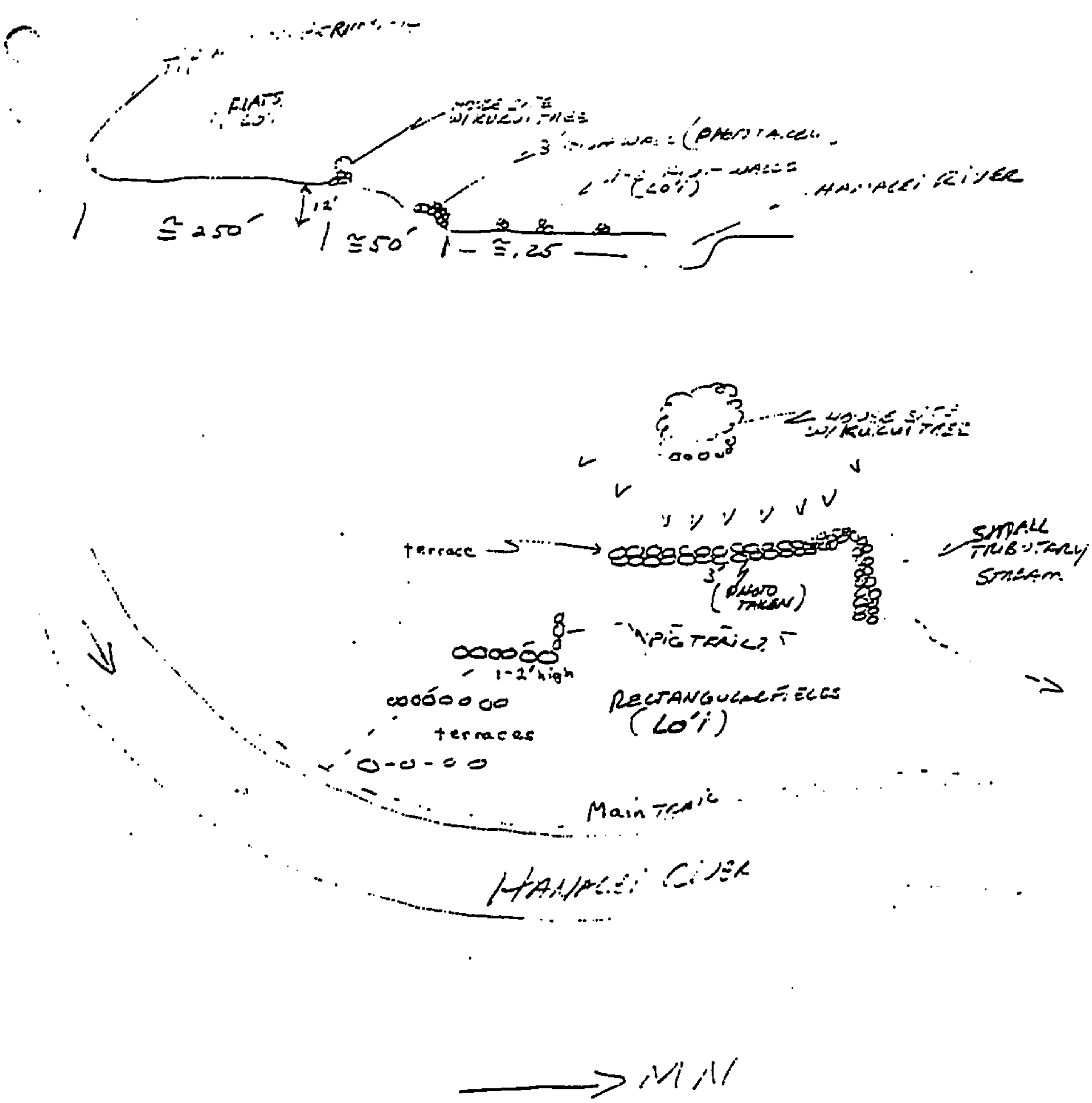


Fig. 10 Field Sketch of Site CSH 9.

rectangular l'oi. The rectangular fields (l'oi) are oriented with their long axis perpendicular to the Hanalei River. The terrace walls are visible as single or double alignments of water rounded boulders, that range in height and width from 1-3 feet. This system or complex appears to have been watered directly from Hanalei River, at a bend in the river, at the mauka or south end of the complex. The complex covers an area of approximately 400-600 feet east/west by 800-1000 feet north/south.

SITE CSH #11 is a complex of agricultural terraces on a river plain on the west side of Hanalei River. The terrace walls, of stacked water rounded boulders, form a rectangular field or l'oi. The walls are up to 2.5 feet high and average 2 feet wide. A minimum of six (6) terrace walls were observed, with their long axis oriented perpendicular to Hanalei River. This complex or system could have been watered from either a small tributary stream at the south (mauka) end or from the Hanalei River itself. Presently there is a large natural looking drainage channel at the back (west side) of the complex. The channel or possible auwai is at the base of a steep cliff with the lo'i located on the river plain between the channel and Hanalei River. The channel ranges in width from 5 to 10 feet and in depth from 3-6 feet with no observed built-up embankments.

SITE CSH #12 (Fig. 11) is a small dam-like structure on the upslope (east) side of a cleft in a bedrock outcrop. The site is located on the east side of Hanalei River with the dam in a small tributary stream. The dam structure is 12 feet long by 3.5 feet wide and 2.5 feet high. It is constructed of stacked water rounded boulders, purposefully slowing down and diverting some of the tributary stream flow as it goes through the cleft, towards Hanalei River. The cleft is approxiamtely 3 feet wide and up to 15 feet from the top of the outcrop to the stream bed. At the bottom end of the cleft the natural stream bed bends to the north, then to the west where it enters Hanalei River. The area around the dam and cleft, especially to the north, is relatively steep and uneven terrain and no other structures, terraces, auwai, etc. were observed. However, there is the possibility that the dam was used to divert the tributary stream to the south, where the terrain is less steep, to water the area towards Hanalei River.

SITE CSH #13 (Fig. 12) is a rough boulder platform, on the north side of a small tributary stream, on the west bank of Hanalei River. The platform is presently 15 feet (N/S) by 30 feet (E/W) but the portion of the south side has probably been eroded away by the tributary stream. Construction of the platform is stacked water rounded

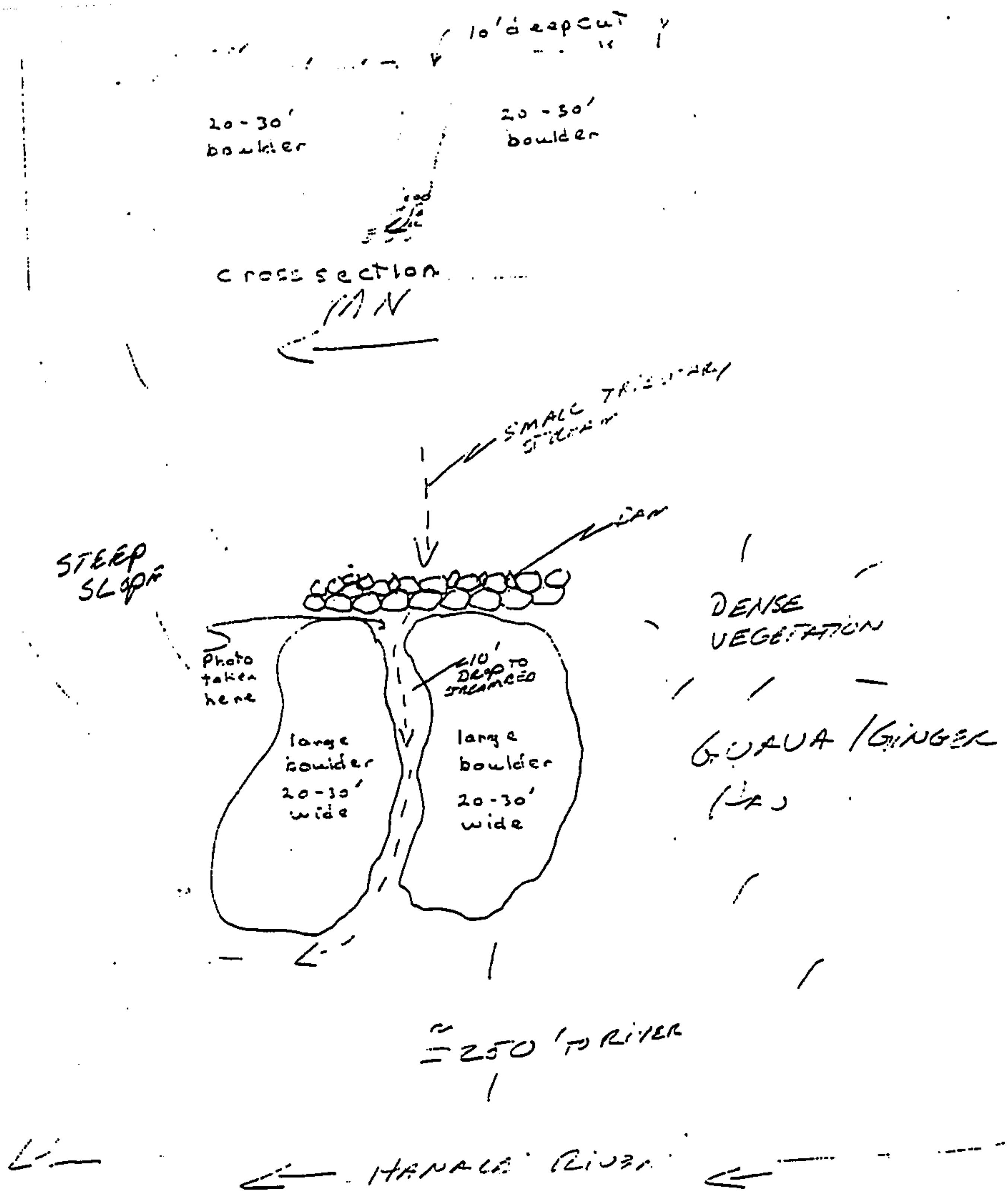


Fig. 11 Field Sketch of Site CSH 12.

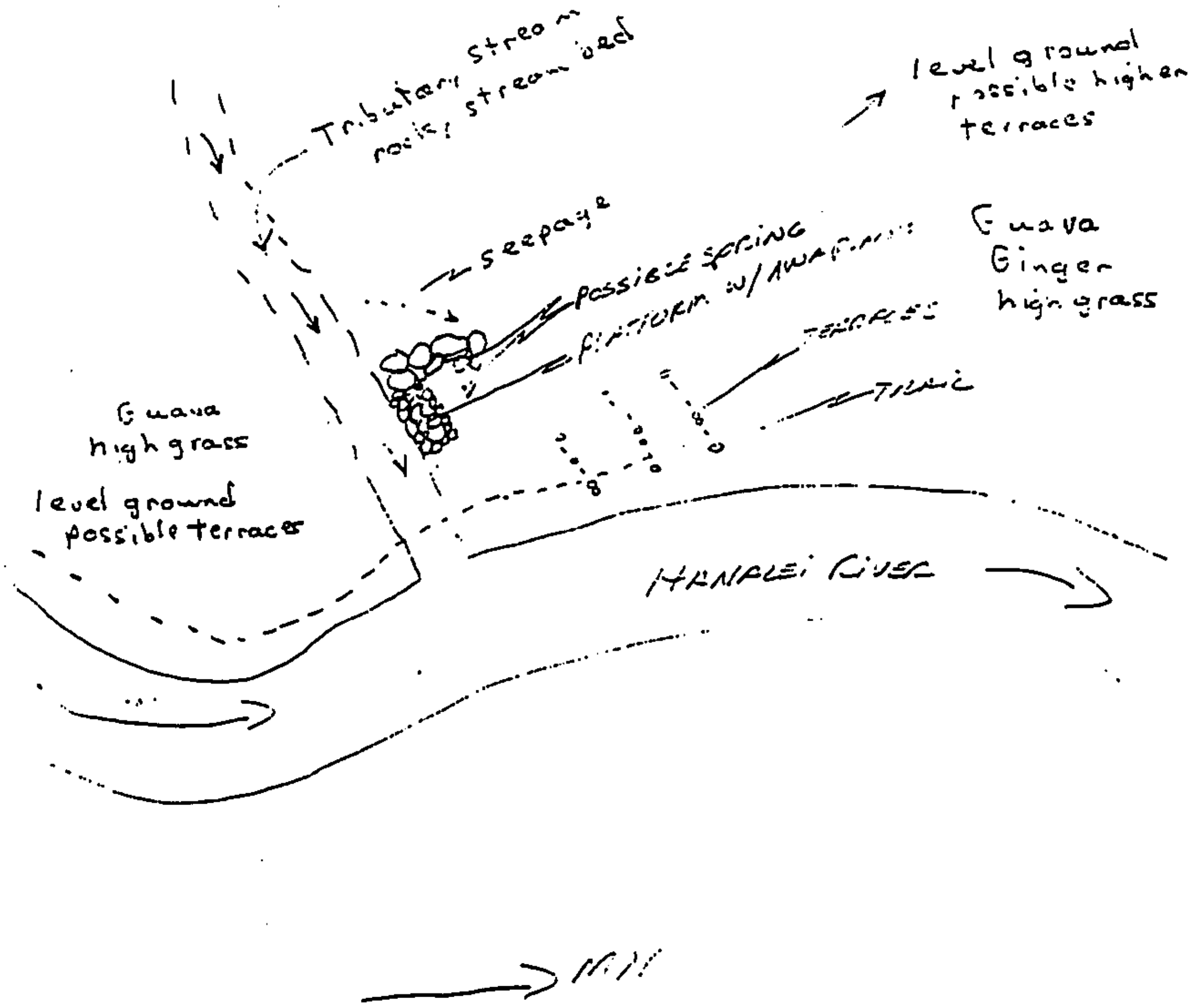


Fig. 12
Field Sketch, Site CSH 13

boulders to a maximum height of 3.5 feet. There is a large clump of 'Awa (*Piper methysticum*) growing along the sides and in front (east) of the platform. Next to the platform, on the north side, is a natural embankment of large boulders, up to 4 feet in diameter, with a possible small spring outlet at their base. The spring sends a trickle of water down towards the 'awa plants and Hanalei River. Makai or north of the platform is a series of barely discernible terrace walls. The terraces are distinguishable as short sections of single alignments of water rounded boulders oriented perpendicular to Hanalei River.

SITE CSH #14 is a series of terrace walls along the east bank of the Hanalei River. These terraces are on relatively high sloping ground approximately 40 to 80 feet above Hanalei River. The terraces were visible as alignments, up to 2 feet high, of water rounded boulders oriented to parallel to the northwest facing slope. The ground around these terraces was considerably dryer than other terracing observed in the Valley and they may indicate dry land agriculture. However, watering of these terraces is possible by small tributary streams upslope (southeastward).

VI. BENNETT'S SURVEY AND POSSIBLE CORRELATIONS

Wendell Clark Bennett conducted an archaeological survey "to record what is known of the archaeology of Kauai." The survey was undertaken during "nine months of fieldwork in 1928-29 (and was) supplemented by study of available collections, of published literature and of manuscript notes on file in Bernice P. Bishop Museum" (Bennett 1931:3). Bennett recorded 5 sites for Hanalei, 3 of which are directly associated with the present project area. These sites and their possible correlations to sites we found are presented below:

> "Site 141 Heiau and house sites, at Kalama-iki, an old village on the river flats, four miles up Hanalei Valley.
>
> There is a stone structure 18 x 20 feet with walls all around 2.5 feet wide and 2 feet high. in front is a paved section extending 5 feet, like a lanai, to a drop of 4 feet of the river terrace. The river is 50 feet out in front. Both river stones and rough rocks were used, but no coral seen. The wall was chinked with smaller stones in front. Taro terraces and house sites are on the plains along the river." (Bennett 1931:134)

Bennett's field notes indicate that the "stone structure" was called Kalama-iki Heiau by an "old man and old woman" and that it was located on the east bank of the Hanalei River "below Kapaka Hill and Kapaka Heiau" (Site #140 - Bennett Field Notes, M. S. Bishop Museum). The reference to "taro terraces and house sites are on the plains along the river" also include taro terraces and house sites "across the river" (Ibid). No direct correlation to the heiau site was made as no structure of similar description was observed and the location, east side of the river, is out of the project area. However, because of the ambiguity of the stated locations, 4 mile (or so) up Hanalei Valley, and "below Kapaka Hill," the taro terraces on the same side of the river as the heiau (east) could possibly be CSH #14 terraces. The taro terraces and house sites referred to as being "across the river," may be CSH #4, 5, and 6.

"Site #142. Ka'apoku Heiau, inland from Site 141 in Hanalei Valley. This small shrine consists of a paved platform 18 by 20 feet made of rough stones. A village was across the stream." (Bennett 1931:134)

In Bennett's field notes this site is reported to be on the east bank of Hanalei River some 125 feet upslope or eastward of the river. Location and correlation to the present survey sites is difficult without Bennett's original map. However, there seems to be two possible locations as inferred by place names. One, at the top of the project, at the stream valley called Ka'apoko, which enters/converges with Hanalei River from the west. The other is Ka'apahu Stream Valley, approximately 1.5 miles down from the top, which enters Hanalei River from the east. Bennett's overall site map for Kauai, on a scale of roughly 1 inch = 6 miles, puts this site nearer the Ka'apoko Stream convergence. Since the present reconnaissance did not yet cover this area, direct correlation to this site (#142) cannot be made at this time. If, however, this site is associated with Ka'apahu Stream, which is on the east side of Hanalei River, the same side as is reported for Site #142, then evidence of terraces and a small platform structure was observed. These terraces and platform structure were observed during the "March 1st and 2nd walk-through" and are located on the river plain across from Site CSH #9, near the Ka'apahu Stream and Hanalei River convergence.

"Site #143. Ditch and house site, across the river from Site #142 in Hanalei Valley.

> Site also includes taro terraces and a ditch that runs from 0.5 mile or so up the stream to water this plain. The water comes through a big rock which is conveniently cracked. The legend runs that Pele sent lightning to split the rock so that the people could get the water down to the fields. Upstream from here a large, overhanging rock forms a natural shelter. It has been built up along the front a bit. The house sites of the solidly paved type as well as those merely outlined with stones, are found." (Bennett 1931:134).

The possible location(s), as they relate to the present reconnaissance, of this site have been discussed as part of Site #142. For if Site #142 is located in association with Ka'apahu Stream Valley, then this site (#143) probably correlates to CSH #9, terrace complex and probable house sites. However, no 0.5 mile long ditch which is fed through a "crack in a large rock" was observed as part of CSH #9.

Adding further confusion to the situation is a "crack in a large rock" or "split in a big lava flow," as it is referred to in Bennett's field notes, was observed in our survey and is described as CSH #12. However, Site CSH #12 is located at about the midpoint of the project area, on the east bank of Hanalei River, well below either Ka'apoko or Ka'apahu Streams.

Bennett's reference to the overhang shelter, correlates very well with our Site CSH #8. CSH #8 is a large overhang shelter located on the west side of Hanalei River, approximately 1500 feet mauka (south) of the project area, not far above the Ka'apoko Stream and Hanalei River convergence. The location of the shelter according to Bennett is "upstream from here" (Site 143), seeming to indicate a relatively short distance. Thus inferring that Sites #142 and #143 are probably located near the top of the project, in the area of Ka'apoko Stream. Other possible "clues" placing #142 and #143 at Ka'apoko Stream is the use of the word "stream" in describing the 0.5 mile ditch and a photograph of the area (Appendix) which shows a narrow water course between a large rock or split in the ridge on the west bank just makai (north) of the Hanalei River and Ka'apoko Stream convergence - suggesting that the ditch or auwai tapped Ka'apoko Stream, not Hanalei River, and that the "crack in a large rock" is the one shown in the photograph.

Also within Bennett's field notes are some of his general impressions of Hanalei Valley.

He states that "Villages in bends of river - well scattered houses in locations but for the most part living was poor as ground is steep and wet." Also, "Valley very overgrown - much rain and - constant attention would be necessary to keep weeds down in cultivated spots - many mountain apples - oranges - awa root - fish - guava Hawaiian asparagus." And . . . "Steep contours and mud would be unfavorable for living - river floods almost all flats during rainy and flood seasons - would wash out many dwellings." (Bennett Field Notes, M. S. Bishop Museum Library.)

It appears as if Bennett wrote these general impressions of Hanalei Valley while spending the night in the overhang shelter (CSH #8) which he felt was "probably used for a long time for shelter." The notes indicate that Bennett did not go further up the Valley, though he was informed that there may have been more sites mauka (south) of the shelter. These general notes suggest that the very thick jungle-like vegetation was as serious an impediment to archaeological surveying then as it is now.

VII. SUMMARY AND SIGNIFICANCE EVALUATIONS

A total of fourteen site areas were located in this reconnaissance survey. Summary information on these areas is presented in the table below.

Generally there are three types of sites: 1) rock shelters; 2) historic house sites, and 3) agricultural terraces, some with associated house sites and auwai.

Both of the rock shelters found are located mauka of the project area. Site CS7 is a small dry overhang used today by marijuana growers. it does contain floor deposits but no sign of cultural material was observed. Site CS8 rock shelter appears to be a major landmark in the upper portion of the valley. It has an excellent overlook view down valley and is high enough to be protected from river flooding and the overhang is permanently dry. Bennett spent the night here in 1928 or 1929 and today it is a well supplied marijuana growers camp. This site must have been used in prehistoric times and the floor deposits probably contain stratified cultural deposits with datable organic materials. A chronological framework for Hawaiian use of upper Hanalei Valley would begin with excavations at this site. Howver, the locality would not be impacted by the proposed hydroelectric project and negotiating with the current users of the shelter would be delicate.

TABLE 1. SUMMARY TABLE, UPPER HANALEI VALLEY

Site No.	Location	Description	Comments
CS1	West side of River near proposed power house	Historic house site and abandoned auwai	Correlates to house location on 1916 map. Auwai may be former "China Ditch"
CS2	West side of River	China Ditch intake	Supplies water to present Hanalei taro fields on west side of River
CS3	West side of River near present trail	Historic house site	Correlates to house location on 1916 map
CS4	West side of River	Historic house site, wall and terraces, and abandoned auwai	Housesite correlates to location on 1916 map. Wall and terraces probably prehistoric. Could be part of Bennett's site, 141.
CS5	West side of River by trail	Platform, with bowl carved in rock by trail	Possibly prehistoric site. Terraces could occur nearby
CS6	West side of river by trail	Terraces	Probably prehistoric
CS7	East side of River above Kaapoko Stream	Small rock shelter	May contain buried cultural material; prehistoric
CS8	East side of River above Kaapoko Stream	Rock shelter with good overlook down valley	Contains floor deposits; probably prehistoric; visited by Bennett

Site No.	Location	Description	Comments
CS9	West side of River below Kaapahu Stream	Housesite and terraces	Probably prehistoric; terraces extend upslope, probably more extensive than observed; terraces parallel to River
CS10	East side of River above Pekoa Stream	Terraces - at least eleven terraced field levels	Prehistoric; terracing probably covers entire point bar. Terraces perpendicular to River.
CS11	West side of River opposite Pekoa Stream	Terraces - at least six levels	Prehistoric; terraces perpendicular to River; probably cover entire point bar.
CS12	East side of River	Dam wall above large split boulder	Dam is for water control; terraced fields probably associated. Split rock similar to Bennett's site 143.
CS13	East side of River by trail	Rough platform; awa plants	Prehistoric; could be house site or water control; terraces to north are perpendicular to River
CS14	West side of River by trail	Formal terraces on high ground	Prehistoric; could be dry land terraces (unirrigated)

The historic house sites CS1, CS3 and a feature of CS4 all appear to correlate to locations of houses on the 1916 U.S.G.S. map (Fig. 4). Although in some cases house foundations were not visible (they were probably elevated wooden frame structures), bottles scattered about indicate use in the 1920's. It is probable although not certain that the economy of this settlement was supported by wetland irrigation and that terraces in this lower portion of the project area were used continuously from prehistoric times through the 1920's. These sites are of archaeological value in their potential for dating and characterizing historic use of the area and for documenting what appears to be progressive historic abandonment of the Valley. However, much of this information could be obtained effectively through informant interviews and historical search as a complement to archaeological methods. Of these 3 historic sites only CS1 is close to the proposed pipeline, although it is possible that terraces associated with all these sites could be impacted.

Site CS2, the present intake for the China Ditch which now supplies irrigation water to Hanalei taro fields is a modern feature and technically not a historic site. However, the ditch itself, or portions of it, was probably in use for many centuries. The abandoned auwai located at CS1 and near CS4 may be former routes or tributaries of the same ditch network.

Terraced agricultural complexes, some with house sites, include CS4, CS5, CS6, CS9, CS10, CS11, CS12, CS13 and CS14. These site areas as a group, particularly those in the upper portion of the valley, show evidence of extensive wetland cultivation almost certainly of the late prehistoric period. These sites are significant in the context of ancient Hawaiian social evolution and economic adaptation. Earle (1978:163) in his study of Halele'an taro cultivation and social organization argues that irrigated lands were under-utilized in the main portions of the valleys and never extended into the less accessible, narrower parts of the valley and that dry land terracing on the slopes was not generally practiced. However, Bennett (1931:36) found terraces far back in Wainihi Valley even where it constricts and steepens (see also Handy and Handy 1972:419-420). Shilt documents dry land terracing on the slopes of Hanalei Valley (Schilt 1980:66). (See also Cordy 1974 for Lumahai Valley.) The significance of all this is that the expansion of late prehistoric agricultural land use in Hawaii is a measure of response to population pressure and political and social consolidation. The present reconnaissance survey confirms the presence of irrigated and possibly dry land agriculture into the remote lands of upper Hanalei Valley and once again confirms that the value of potentially productive lands to prehistoric Hawaiians and their ingenuity in developing them should not be underestimated.

Water availability was probably never a constraining factor in the Valley but flooding was a constant possibility. In all the terrace systems observed, the source of water was probably a tributary stream because these sources would be easier to channel to the higher parts of the point bars and more easily controlled in time of flood. Tributary streams that were potential water sources are easily discerned at CS9, 10, 11, 12, and 13. Site CS14 was the only area where terraces were observed on high ground and may be the single example of dry land agriculture located in this reconnaissance.

Given the obvious constraints of this reconnaissance -- the most important being the dense vegetation -- it was not possible to define the upslope limits of these terraced site areas or the exact location and complexity of the auwai systems that watered them. It is almost certain that some site areas present even adjacent to the river were not located in this reconnaissance. The survey gap from the intake structure to the October 4 drop-off when it is surveyed will probably add more sites to this inventory, particularly if Ka'apoko is Bennett's ka'apoku site area as the similarity in place names would seem to indicate.

VIII. RECOMMENDATIONS

Rock shelters CS7 and CS8 are outside the project and would not be impacted. CS10, 12 and 14 are on the east side of the river and would only be impacted by possible secondary activities such as roads, staging areas, etc. Site CS3, 4 and 5 are to the west of the pipeline but the terraces of CS4 could extend to the river bank. The terraces of Site CS6 would also probably be impacted. Sites CS9, 11 and 13 site areas are definitely in the path of the proposed pipeline and would be directly impacted by the presently planned route of the pipe.

Because of the constraints of this reconnaissance (mostly dense vegetation), the boundaries of these site areas are not well defined. There could be other as yet undiscovered sites on other point bars which were not examined. These sites in some cases could extend at least for a short distance up tributary streams where side intakes are planned.

For these reasons, a more thorough survey is recommended for the exact route of the main pipeline as well as the tributary intakes. Taking into account our experiences in this reconnaissance, this survey should be undertaken after the pipeline corridor has been surveyed and at least partially cleared of vegetation.

At the completion of this survey it should be possible to accurately define site boundaries in relation to the exact pipeline route to find other as yet undiscovered sites. There are 4 major point bars along the pipeline route not covered in this reconnaissance that may contain archaeological sites.

On the basis of such a survey, mitigative action can be recommended such as adjusting the pipeline route or further documentation of sites if impact is unavoidable.

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X. APPENDIX

(Photograph Figures)

Fig. 13 Site CSH 2
Intake area for China
Ditch.

Fig. 14 Site CSH 4
Wall at North end.

Fig 15. Site CSH 5
Stone structure in
Bamboo Grove.

Fig 16 Site CSH 5
Bowl carved in Rock.

Fig. 17 Site CSH 8
Rock shelter

Fig. 18 Site CSH 8
Aerial View, Rock-
Shelter in lower left.

Fig.19 Site CSH9
Terrace wall

Fig.20 Site CSH12
Stream flowing through
split rock. View down-
stream.

Fig.21 Site CSH12
Dam at mauka end
of split rock.

Fig. 22 Site CSH-13, Platform with Awa bushes.

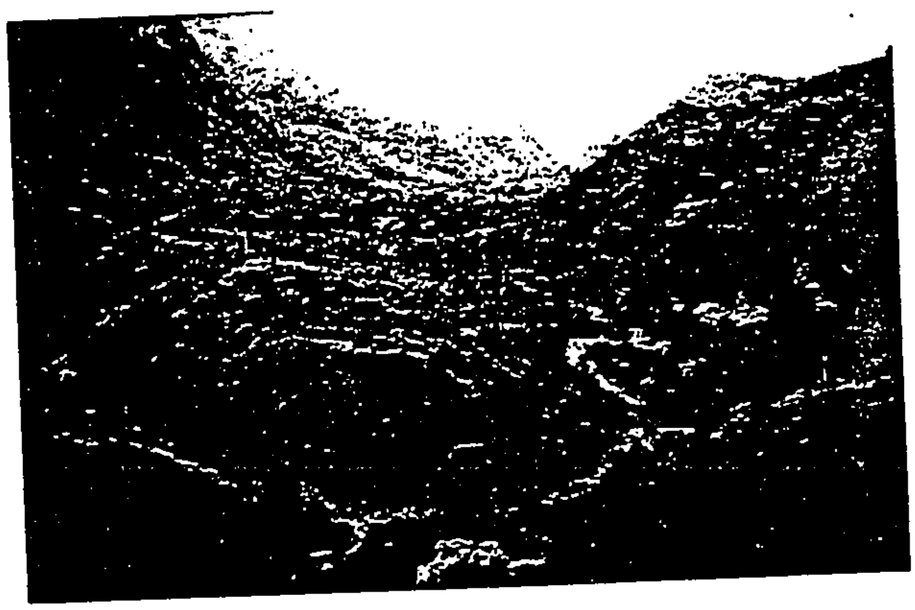

Fig.2.3. View down Hanalei River showing confluence with Kaá-poko Stream (entering from left.

Fig 24 View down Hanalei River, confluence with Kaápoko Stream (this may be one of Bennetts site areas)

Fig. 25 View of Hanalei River above Ko'āpoiko Stream. View Mauka

Fig. 26 Botanist crossing Hanalei River

Fig. 27 View of Waipunaea Falls showing thick hau forest.

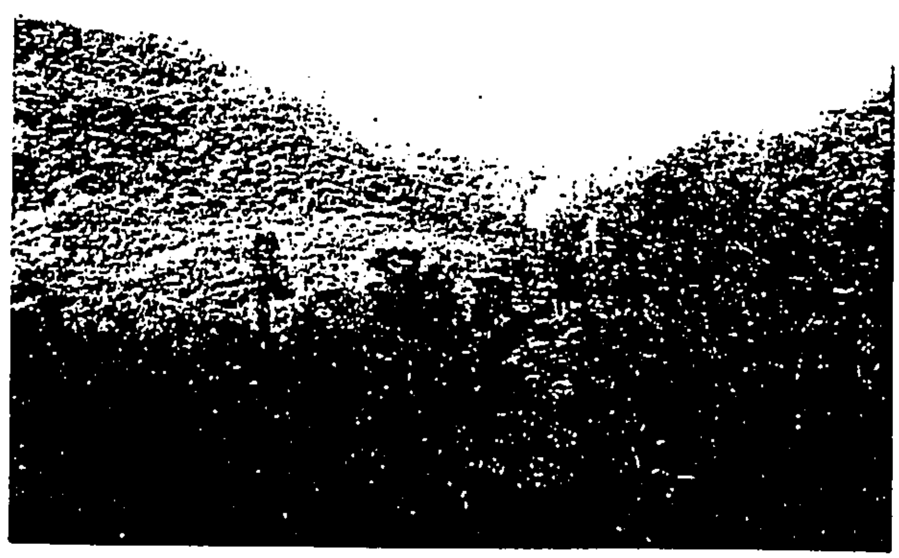

Fig. 28 Hanalei River upstream of Wai-punaea Stream.

Fig 29 Hanalei River rapids above Wai-punaea Stream.

Fig. 30 Hanalei River Valley View makai below Kaápoko Strm showing point bars with kukui trees.

Fig 31 Broad grass covered point bar of Hanalei River below Pekoa Falls

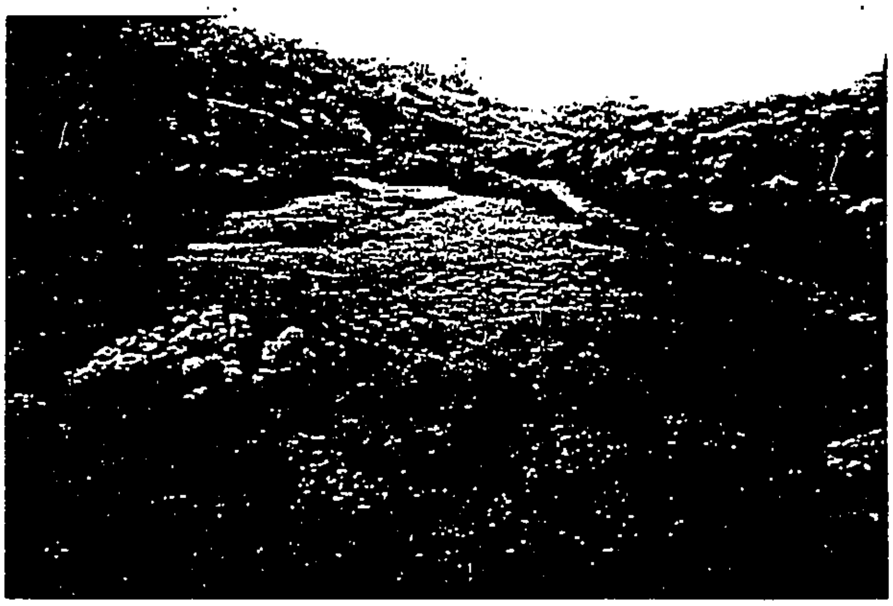

Fig. 32 View down Hanalei River below Pekoa Falls showing broad point bars with Mango trees

Fig. 33 Hanalei River above Pekoa Falls showing point bar.

Fig. 34 Site CSH 7
Terrace wall

Fig. 35 Site CSH 1
Area by Riverbank

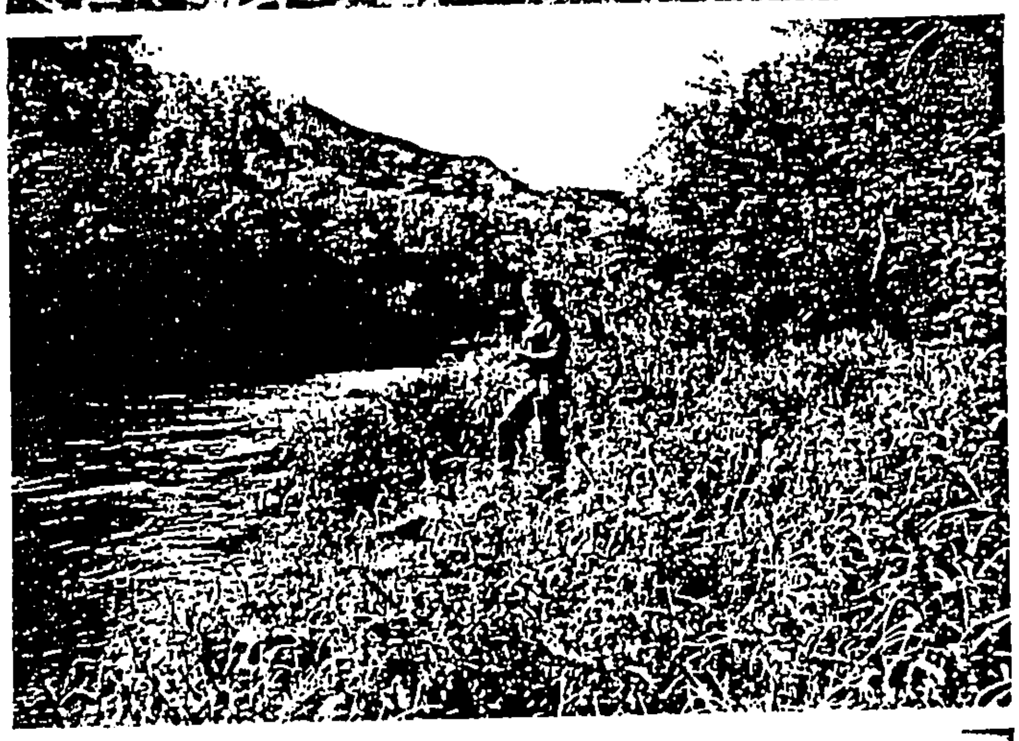

Fig 36 Hanalei River
above Homesteads,
view upstream

Fig 37 Site C-H8 Rockshelter, view upstream

Fig 38 Unnamed tributary valley on west side of Hanalei River below Ka'apoko Stream. This valley is a major land mark from the air.

Fig 39 Hanalei River view upstream at confluence of Ka'apoko Stream (on right). This is the proposed intake area.

APPENDIX V

EFFECTS OF THE PROPOSED HANALEI DEVELOPMENT ON SOIL LOSS BY CORBIN A. BENNION, P.E., JANUARY 1987.

EFFECTS OF THE PROPOSED HANALEI DEVELOPMENT ON SOIL LOSS

BY:

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Prepared For:

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Salt Lake City, Utah 84116

January 1987

EFFECTS OF THE PROPOSED DEVELOPMENT ON SOIL LOSS

1. Introduction

The purpose of this study is to estimate the soil loss resulting from construction of the proposed Hanalei hydroelectric facility. Minimization of soil erosion potential is evaluated using various techniques such as mulching and revegetation.

2. Universal Soil Loss Equation (USLE)

The USLE as used in this report will show the difference between soil loss experienced under existing and proposed conditions for the disturbed areas only. All other areas are assumed to be at or near the natural norm for erosion.

The complete USLE is A = RKLSCP.

Following is the definition of all components of USLE:

A - Computed Soil Loss

A is the computed soil loss derived from sheet and rill erosion in tons per acre per year. This represents onsite erosion from a defined parcel of ground rather than sediment delivered to some point on the stream system.

R - Rainfall Erodability Factor

The energy of moving water detaches and transports soil material. The energy-intensity (EI) parameter measures the total energy of a storm. The sum of the Annual EI units from all storms serves as the R factor.

K - Soil Erodability Factor

The soil erodibility factor is the erosion rate per unit of erosion index for a specific soil cultivated continuous fallow, on a 9% slope, 72.6 feet long.

LS - Slope/Length Factor

These two factors combine to represent: (1) L, the slope length factor, is the ratio of the soil loss from the field slope length to that from a 72.6 foot length on the same soil type and gradient, and (2) S, the slope gradient factor, is the ratio of soil loss from the erodible surface gradient to that from a 9% slope.

C - Cropping Management Factor

The vegetative management factor is the ratio of soil loss from disturbed forest areas to that from a fallow condition of a comparable soil.

P - Erosion Control Practice Factor on Cropland

The erosion control factor P is the ratio of soil loss of the support practice to the soil loss with up and down hill culture.

3. Computation of Soil Loss

Following is a summary of the determined value for each of the components of the USLE and the source or procedure used in determining that value. The procedures, graphs, and figures used to determine the value for each component were derived from a booklet entitled "Procedure For Predicting Soil Loss with the Universal Soil Loss Equation", Technical Guide - Section 1C, August, 1985: Authored by the Soil Conservation Service office in Honolulu, Hawaii.

R - Rainfall Erodability Factor

The average annual value for the rainfall erodibility factor R in the project area is determined to be 400 as derived from the Page 15-R map of the Island of Hawaii.

K - Soil Erodability Factor

Following is the tabulation for computing the weighted "K" value due to five different soil types being mapped along the penstock corridor. The soil types were obtained from the Soil Conservation Service (SCS) soil survey for the Island of Hawaii.

(1) Soil Type	(2) Area (Acres)	(3) Percentage of Area (%)	(4) K Value	Weighted K Factor (Col. 3 X 4)
AtE - Hanamaulu	2.03	7.8	0.10	.0078
KuL - Kilokolo	3.03	11.6	0.28	.0325
rRt - (Assumed similar to Hanamaulu)	12.93	49.4	0.10	.0494
HrB - Hanalei	7.92	30.3	0.17	.0515
HsB - Hanamaulu	0.24	0.9	0.10	.0009
			Weighted K	0.142

LS - Slope/Length Factor

Length The maximum length in the slope direction will be 30 feet which corresponds to the width of the construction corridor.

Slope The average cross-sectional slope along the corridor has been determined to be 38.4%.

From Table 2 on Page 19 the slope/length factor has been computed by interpolation to be 6.44.

TABLE 2.--SLOPE-EFFECT (LS) VALUES 1/

Percent slope	Slope Length (feet) 25	50	75	100	150	200	300	400	500	600	800	1,000
0.5	0.065	0.080	0.091	0.099	0.112	0.122	0.138	0.150	0.160	0.169	0.185	0.197
1	.085	.105	.119	.129	.146	.159	.180	.196	.210	.222	.242	.258
2	.133	.163	.185	.201	.227	.248	.280	.305	.326	.344	.376	.402
3	.190	.233	.264	.287	.325	.354	.400	.437	.466	.492	.536	.573
4	.230	.303	.357	.400	.471	.528	.621	.697	.762	.820	.920	1.01
5	.268	.379	.464	.536	.656	.758	.928	1.07	1.20	1.31	1.52	1.69
6	.336	.476	.583	.673	.824	.952	1.17	1.35	1.50	1.65	1.90	2.13
8	.496	.701	.859	.992	1.21	1.40	1.72	1.98	2.22	2.43	2.81	3.14
10	.685	.968	1.19	1.37	1.68	1.94	2.37	2.74	3.06	3.36	3.87	4.33
12	.903	1.28	1.56	1.80	2.21	2.55	3.13	3.61	4.04	4.42	5.11	5.71
14	1.15	1.62	1.99	2.30	2.81	3.25	3.98	4.59	5.13	5.62	6.49	7.26
16	1.42	2.01	2.46	2.84	3.48	4.01	4.92	5.68	6.35	6.95	8.03	8.98
18	1.72	2.43	2.97	3.43	4.21	4.86	5.95	6.87	7.68	8.41	9.71	10.9
20	2.04	2.88	3.53	4.08	5.00	5.77	7.07	8.16	9.12	10.0	11.5	12.9
25	2.95	4.17	5.10	5.89	7.22	8.33	10.2	11.8	13.2	14.4	16.7	18.6
30	3.98	5.62	6.89	7.95	9.74	11.2	13.8	15.9	17.8	19.5	22.5	25.2
40	6.33	8.95	11.0	12.7	15.5	17.9	21.9	25.3	28.3	31.0	-	-
50	8.91	12.6	15.4	17.8	21.8	25.2	30.9	-	-	-	-	-
60	11.6	16.4	20.0	23.1	28.4	-	-	-	-	-	-	-

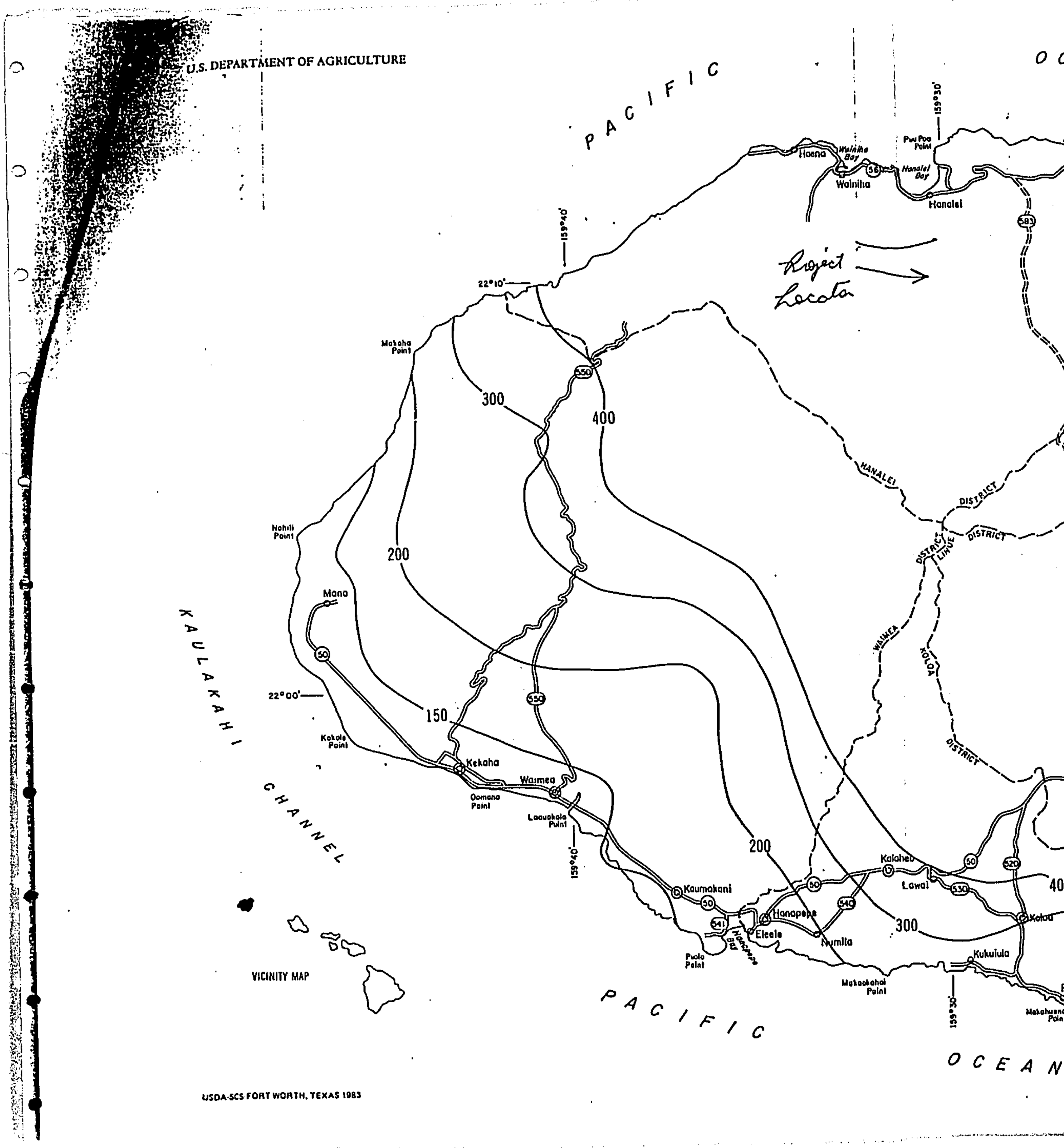
1/ Based on the formula:

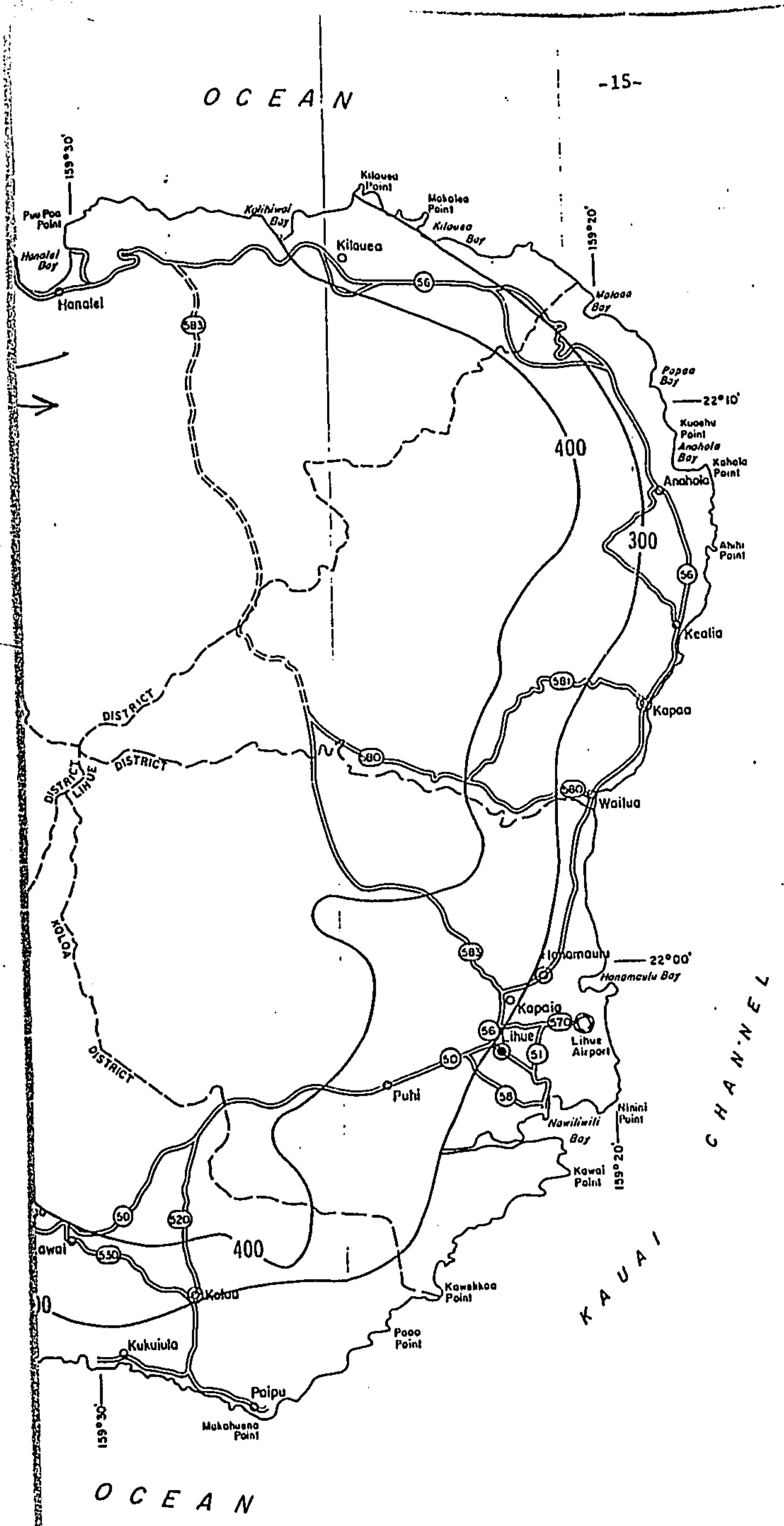
$$LS = \left(\frac{\lambda}{72.6}\right)^m \left(\frac{430x^2 + 30x + 0.43}{6.57415}\right)$$

where m = 0.5 if s = 5% or greater, 0.4 if s = 4%, and 0.3 if s = 3% or less; and x = sin θ.

Values shown for slopes of less than 3%, greater than 18%, or longer than 400 feet, represent extrapolations of the formula beyond the range of research data.

August 1985


U.S. DEPARTMENT OF AGRICULTURE
PACIFIC
OC
Project Locata
Haena
Wainiha Bay
Wainiha
Puu Poa Point
Hanalei Bay
Hanalei
159°30'
159°40'
22°10'
Makaha Point
300
400
200
150
HANALEI
DISTRICT
LIHUE
WAIMEA
KOLOA
Nohili Point
Mana
22°00'
Kokole Point
Kekaha
Waimea
Oomano Point
Laauokala Point
KAULAKAHI CHANNEL
Kaumakani
Hanapepe
Eleele
Hanapepe Bay
Puolo Point
Numila
Kalaheo
Lawai
Koloa
Kukuiula
Makaokahai Point
Makahuena Point
VICINITY MAP
PACIFIC
OCEAN
USDA-SCS FORT WORTH, TEXAS 1983



AVERAGE ANNUAL VALUES OF RAINFALL FACTOR R

KAUAI COUNTY

ISLAND of KAUAI

HAWAII

OCTOBER 1982

0 1 2 3 4 5

APPROXIMATE SCALE - MILES

JANUARY 1983 4-R-38102

C - Cropping Management Factor

Condition	"C" Value	Source
Existing	.008	Table 5 - Page 21
Post-clearing, no control	1.0	Table 7 - Page 23
Post-clearing, short term control (Mulching with hay at 2 tons/acre)	.02	Table 7 - Page 23
Post-clearing, long term control (Permanent grosses)	.01	Table 7 - Page 23

The "C" value for the existing condition was determined to be the average of canopy of short brush with 80 to 100 percent ground cover.

P - Erosion Control Practice Factor or Cropland

As shown in Table 8, page 23, the P factor of 1.0 was determined for up and down slope farming with a slope in excess of 24%. Although contour furrowing and planting would decrease the P factor, we have left the P value at 1.0 for all conditions.

A - Computed Soil Loss

The computed soil loss for various conditions using the USLE equation are shown in Table 1. Please note the following which show the calculations to be conservative.

1. The final column in Table 1 shows the estimated erosion on a six month basis. With the combination of proposed mulching and reseeding the vegetation should be effective in less than six months.

2. The average cross slope of the existing ground will be 38.4%. However a cut and fill operation to provide a bench to place the penstock will result in a steep face and then a level bench.

3. A naturally vegetated strip of at least 10 feet wide will be left between the disturbed area and the stream. This strip will tend to filter the sediment and allow only a portion of the erroded soil to reach the stream.

EROSION CONTROL PRACTICES IN THE CONSTRUCTION AREAS

The limits of clearing and soil disturbances for the penstock corridor and construction areas will be flagged prior to equipment being mobilized to the site. The following summarizes several measures that will be implemented during and after construction activities to minimize soil erosion:

TABLE 5.--C Values [illegible]

Vegetal canopy			Ground Cover (See footnote 5/)					
			Percent					
Type and height 2/	Percent canopy 3/	Type 4/	0	20	40	60	80	95-100
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Apppeciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees, but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.

2/ Average fall height of waterdrops from canopy to soil surface: m = meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

4/ G = cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W = cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) and/or undecayed residues.

5/ The Percent Ground Cover is that portion of the soil surface that is hidden from aerial view by the G and W cover types with a fall height of less than 0.5 m.

TABLE 5.--C Values [illegible]

Vegetal canopy: Type and height 2/	Percent canopy 3/	Type 4/	Ground Cover (See footnote 5/) Percent: 0	20	40	60	80	95-100
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Apppeciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees, but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.

2/ Average fall height of waterdrops from canopy to soil surface: m = meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

4/ G = cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W = cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) and/or undecayed residues.

5/ The Percent Ground Cover is that portion of the soil surface that is hidden from aerial view by the G and W cover types with a fall height of less than 0.5 m.

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TABLE 7.--Values of Ground Cover for Erosion Control on Construction Sites*

Kind of Ground Cover	Value
Grass sod	0.01
Seedlings (based on fully established stand):	
Permanent grasses (rhizomatous or stoloniferous)	0.01
Field bromegrass	0.03
Ryegrass (perennial)	0.05
Small grain	0.05
Millet or Sudangrass	0.05
Ryegrass (annual)	0.10
Mulches:	
Hay (2 tons/acre)	0.02
Small grain straw (2 tons/acre)	0.02
Woodchips (6 tons/acre)	0.06
Wood cellulose fiber (1-3/4 tons/acre)	0.10
Bagasse (2 tons/acre)	0.02

*"C" value for bare soil is 1.0.

TABLE 8.--Erosion Control Practice Factor, P

Mechanical Practices

Percent Slope	Up & Down Slope Farming	Contour Planting	Contour Irrigation Furrows	Cross Slope Farming
.0 - 7.0	1.00	0.50	0.25	0.75
7.1 - 12	1.00	.60	.30	.80
12.1 - 18	1.00	.80	.40	.90
18.1 - 24	1.00	.90	.45	.95
Above 24	1.00	1.00	.50	1.00

Grass Strips in Orchards

Percent Slope	Percent of Field in Vegetated Strips 10	20	30	40	50
1 - 2	0.55	0.50	0.40	0.35	0.30
3 - 8	.45	.40	.35	.30	.25
9 - 12	.55	.50	.40	.35	.30
13 - 16	.65	.55	.50	.40	.35
17 - 20	.70	.65	.55	.50	.40
21 - 25	.80	.70	.65	.55	.45

TABLE 1

ANNUAL SOIL LOSS SUMMARY
HANALEI HYDRO

Condition	R	K	LS	C	P	Reclamation Time Period (Yrs.)	Tons/ Acre/ in 6 Months	Disturbed Area (ac)	Six Month Total Soil Loss Tons
Existing	400	.142	6.44	.008	1.0	0.5	1.5	26.16	39.2
Post-clearing, no control	400	.142	6.44	1.0	1.0	0.5	.183	26.16	4,787
Post-clearing, short term control (Mulching)	400	.142	6.44	.02	1.0	0.5	3.7	26.16	96.8
Post-clearing, long term control (Seeding)	400	.142	6.44	.01	1.0	0.5	1.8	26.16	47.1

1. A key to reducing soil erosion is to minimize the disturbance in the areas around the construction site. The disturbed area is to be flagged in the field prior to construction.

2. Educate construction workers as to the value of the erosion control measures to be implemented.

3. Immediately begin to mulch and/or revegetate disturbed areas as soon as possible after construction of every 1,000 feet of work in the penstock corridor is completed.

4. Install drainage structures in waterways at the beginning of the construction project to carry runoff water from undisturbed drainage across the disturbed corridor.

5. Where possible construct small diversion dikes of soil around the perimeter of the disturbed area to force runoff to collection points. A diversion dike is a temporary ridge of compacted soil immediately above cut or fill slopes and constructed with sufficient grade to provide drainage. A perimeter dike is like the above; however, it is constructed around the disturbance. This is to prevent off site storm runoff from entering and on site runoff from leaving the disturbance.

6. A strawbale dike/trap should be, installed at water collection points (direct runoff by water bars along the penstock corridor when possible. This method of collecting sediment has only a three-month life expectancy but is very effective. Bales need to be anchored securely to be effective.

7. Another important step in stabilizing and reclaiming disturbed areas is to provide a suitable growth media for revegetating the disturbance. Prior to construction, the topsoil should be stripped and stockpiled where possible. Then reapply the topsoil after construction.

8. The basic steps to permanent soil stabilization are:

    1. Provide an adequate growth media for plants by stockpiling all topsoil.
    2. Prepare an adequate seedbed by ripping and discing.
    3. Preferably drill or broadcast seed onto prepared seedbed.
    4. Apply native hay mulch at the rate of 2 tons/acre and crimp into the soil to prevent water and wind erosion.
    5. Plant containerized material.
    6. Monitor the planting and repair of trouble spots.

9. Leave a 10 foot minimum width of undisturbed vegetation between the disturbed areas and the stream edge to act as a filter.